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ABSTRACT

Third in a series on teaching methods in higher education, this updated volume reviews and evaluates research on audiovisual aids and related instructional hardware. While the emphasis is on the effectiveness of technical aids in higher education as instructional tools, some information on technical and administrative problems is also provided. Concern is primarily with British research connected with higher education, with some reference to American and other European findings and to relevant research at other levels of British education and adult life. Specific sections examine the research evidence and then summarize findings on still pictures; moving pictures (films and television); recorded sound; programmed learning and teaching machines; mixed systems and other developments (tapes and slides, multimedia systems, and the feedback classroom, which expands the programmed learning techniques to cover the operation of a whole class); and computers. A summary discussion and conclusions, and a 22-page reference list are included. (LMM)

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Technical Aids to Teaching in Higher Education

Colin Flood Page & John Kitching

Third Edition

IR010925

Society for Research into Higher Education

Colin Flood Page is now retired, after a teaching career covering grammar schools, teacher education, and the universities of Aston, Bradford and London. His recent work has chiefly been concerned with university teaching in all its aspects. He is particularly interested in helping teachers to become full professionals in the best sense of the word.

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FOREWORD AND ACKNOWLEDGEMENTS TO THE FIRST EDITION

In the summer of 1966, the Society for Research into Higher Education organized a meeting for a small group of its members who had expressed an interest in studying methods of teaching relevant to higher education. Some of them were university teachers, anxious to improve their knowledge of educational theory. Others were research workers engaged in the experimental study of teaching methods, or in such fields as psychology, sociology and linguistics, who welcomed an opportunity to discuss their work with a more heterogeneous collection of interested colleagues than would normally have been easily accessible to them.

From this discussion group arose the Working Party on Teaching Methods in Higher Education. In 1968 it asked the Society to publish its first monograph - Objectives in Higher Education - and in March 1970 this was followed by Aims and Techniques of Group Teaching. The present volume is therefore the third, in what has hopefully been designed as a continuing series. Like its predecessors, it has evolved towards its published form through a series of working drafts which have served as working papers into which criticisms and suggestions from the whole working party have been integrated.

The author's final task in the writing of one of these monographs is always to achieve a personal synthesis which takes account of all that has been contributed, and in a form likely to be useful to practising teachers rather than to specialist research workers. Colin Flood Page has been remarkably successful in this and he has produced what must surely be one of the most comprehensive and readable surveys ever undertaken of British research in the use of technical aids. Most of the more relevant studies from outside the United Kingdom have also been taken into account. This is no mere catalogue of gadgets, but an important discussion of the strategies of using resources in the service of curriculum objectives.

W.D. FURNEAUX

Chairman, SRHE Working Party on
Teaching Methods in Higher Education (1970)

Professor of Education, Brunel University — December 1970

In addition to registering my thanks and indebtedness to the members of the Working Party for all that they have done to improve this publication, I would also like to thank for their helpful comments Mr Charles Engel (Director of the Department of Audio-Visual Communication, BMA); Mr Tony Gibson (Director, TV Research and Training Unit, Goldsmiths' College); Mr Hilary Perraton (Director, Inter-University Research Unit, Cambridge); and Professor A.E.W. Miles and Dr F. Smales of the London Hospital Medical College. The Secretary of the Dental Education Research Unit, Mrs I. Howard, merits a special word for her help with many of the more tedious operations that went to the production of this work.

COLIN FLOOD PAGE — December 1970

PREFACE TO THE THIRD EDITION

In the ten years since the first edition of this book appeared there has been much activity in the fields surveyed, but still not enough good research. It remains true that apart from such things as slides, technical aids are little used in higher education, except where teachers' hands are forced, as in the Open University. The micro-chip is the latest technological breakthrough that some have hailed as promising a revolution in teaching. It appears more likely that its impact will be slight, and may, indeed, already have happened in the shape of the pocket calculator. Person-to-person interaction looks like being the dominant mode of education in the foreseeable future, as it always has been. Nevertheless technical aids do have a part to play in helping to promote good learning when wisely used. It is hoped that these pages will enable teachers to see such use in the right perspective.

Colin Flood Page

John Kitching

February 1981

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INTRODUCTION

Among the problems presented to teachers today those connected with audio-visual aids tend to receive a lot of publicity. Suggestions appear in the popular press and on radio and television that by the use of films, teaching machines, closed-circuit television, micro-chips and similar apparatus the fabric of education will be dramatically improved and many of our current difficulties will disappear overnight. In addition a large number of manufacturers and traders are applying heavy commercial pressure on teachers to buy their latest gleaming goods; and behind all these activities and notions there loom vague general ideas about the technological revolution, the benefits it has brought in other fields and the benefits it must therefore obviously bring to education. This brief review presents some of the things that are known about this forbidding array of instructional gadgetry, and in doing so aims to give teachers, it is hoped, a reasonably clear basis for making an assessment of the audio-visual aid problem in their own local situation. As well as evidence and suggestions on those items commonly called audio-visual aids, some facts and ideas will be offered about related apparatus, including such things as computers and teaching machines. We have used the term 'technical aids' as a convenient bit of shorthand to refer to this diverse collection of assorted hardware. In effect we shall be dealing with a sizeable fraction of the non-human mediators of learning and attempting to show what is known about their functions in higher education. For those who wish to know in more detail exactly what is available there are numerous, often quite massive publications, eg British Universities Film Council (1977), Howe and Romiszowski (1978), and Pitcher (1978).

As in other fields of applied technology, the educators and technicians of the United States have not been slow in developing and using audio-visual aids on a large scale, and there is a plethora of books and articles on the subject. In this short work it is not our intention to summarize all this huge corpus of material, especially as most of it consists of descriptive and/or technical reports, and there is comparatively little that can be reasonably called research. To keep things within manageable compass the survey will be based principally on British work connected with higher education with some reference to American and other European findings, and to relevant research at other levels of British education and adult life. (Additional references may be found in Coppen, 1972, and Harrison 1966.)

The survey is complicated by the fact that much of the research and development that has taken place has been based on erroneous notions as to the function of non-human aids in education. There has been a tendency to see them as direct competitors with human teachers, and therefore as threats and as objectives of fear and mistrust.* The problems that have been posed have often been concerned with

* Tobias (1968, 1969) has investigated these feelings among American schoolteachers, and has found that even the nomenclature used may be a significant factor in how much fear is felt.

such things as a comparison of the efficiency of a course of lectures presented on videotape with a course presented in the flesh; but it is now being realized that this kind of comparison is of doubtful value, as it is based on a fairly superficial analysis of the educational problem (Center for Research on Learning and Teaching 1967), which assumes that the precise method by which material is presented must be a highly significant factor in causing students to learn. This assumption may be true in some cases, but it should not be taken as self-evident any more than the assumption that the visible tip of an iceberg is the significant factor that controls the invisible nine-tenths. In British higher education in particular, the highly selected student body is probably less affected by changes in teaching method than are less rigorously chosen groups. Teaching methods have been regarded as the important factor in many experiments, without prior analysis of the total situation to try and decide which are the important factors. The modern approach of systems analysis, which attempts this vital initial weighing up of all the relevant factors, may well suggest that in a given instance teaching methods per se are only of marginal significance. Such things as personality differences among the students or the attitudes of teachers may be of much greater importance. In the course of a lucid discussion of this problem entitled 'The Uses and Abuses of Negative Results' Gruber (1968) indicates what slight significance an alteration in teaching methods may have from the student's point of view. A significant part of his analysis is reproduced in a later part of this monograph.

Part of the confusion has arisen because, in connection with so many of the aids we are considering, there are at least three distinct classes of problem which have not been properly differentiated. These three classes are intimately related, and a full account must be taken of all of them in a proper analysis; but the ultimate aim of the educational process has tended to be lost to sight in many studies of audio-visual aids among a welter of other considerations. The installation of a closed-circuit television network for instance, illustrates reasonably clearly what these three classes are: technical, administrative (including financial), and instructional. What sort of cameras, studios, recording facilities are needed? Who is going to organize, maintain, and pay for the equipment? What effect will this particular way of presenting visual material have on the learning and teaching that goes on in any particular institution? This last set of questions is the vital one for which the other two help to prepare the ground; but a large part of what has been written on the subject has been too much concerned with the first two sets, with administrative and technical problems. The teacher seeking guidance as to how the new machines will affect the quality and quantity of learning has gone away empty handed and confused by mysterious electronic data, or disheartened by the expenditure of time, money and people apparently necessary to get things going. People have become enamoured of the new machines, and have rushed ahead to install expensive apparatus without any serious considerations as to whether specific instructional benefits can be expected to follow the installation. Barrington's careful review (1965) throws considerable doubt on the notion that TV, as currently used, has any specific educational value in the ordinary school situation commensurate with the cost of providing it. As Stephen Leacock (1911) clearly demonstrated some time ago, it is usually far easier to get large sums out of committees for unspecified and probably useless purposes than to extract small sums for definite and useful purposes; and it is not unknown for expensive machines to stand idle in classrooms where simple things like books and paper are in short supply. A thorough consideration of several hundred studies of

instructional TV, mostly American, (Chu and Schramm 1968) comes to conclusions similar to those of Barrington. Educational TV can be effective in the right circumstances, but too often it has been used in the wrong way in the wrong place with the not unexpected result that it has produced no benefit for either students or teachers. Properly tailored use of the medium is another matter.

The analysis of the educational process in which technical aids are involved has tended to be, as we have said, superficial and/or misguided. This is not surprising. It is almost inevitable that pioneers in any field of human activity waste time wandering down blind alleys and amassing unwanted gear which later workers regard as cumbersome and irrelevant. For instance, in a video system considered from the learner's point of view (and the educational system is theoretically set up to benefit the learner), the important questions are not whether the visual material with which he is presented is delivered by film projector, television, epidiascope or anything else. The important things as far as he is concerned are the sequence in which material is presented, the clarity of the pictures, their relevance to what he is supposed to be learning, their consonance with his interests, and so on. Technical questions about the way apparatus works, or administrative questions concerning the availability of projectors, etc, only obtrude significantly on the teacher's or learner's attention when things go wrong, and the prime purpose of learning is interrupted. On the other hand there is usually an optimum point, a threshold beyond which further technical refinements only add to expense and have no discernible effect on learning, however much they may delight the expert. Consideration of these other matters must have a place in a full analysis; but must not be allowed to obscure the essential issue. Unfortunately, in practice, many a teacher's honest attempt to use new methods and machinery is so handicapped by technical trouble and/or bedevilled by organization problems that he reasonably rejects the innovation. Too many enthusiastic researchers and electronic devotees do not seem to understand how exasperating and off-putting such experience can be. So much time and nervous energy does the teacher have to expend on the technical and organizational problems that he has little left to devote to the specifically instructional ones. Considering such well-known facts as these, it is perhaps not surprising that the surveys already mentioned (Barrington 1965; Chu and Schramm 1968) demonstrate that so little benefit has been gained from so much glossy hardware. Difficulties which bulk large for the teacher have been brushed aside as unimportant by those recommending the new techniques. In other words: the analysis of what has to be done and how it is to be done has not taken into account the right variables with the right weights. It is often the case that it is only when the technical and administrative problems are thoroughly under control that the central problems of the improvement of learning can be adequately tackled. In practice this means that any attempt to introduce technical aids must be accompanied by an apposite provision of staff and of maintenance and storage facilities to make sure that the machines are always available and operational when required. Both they and the teachers can then do their jobs properly.

While bearing these general conditions in mind the account we offer will aim to deal principally with the effectiveness of technical aids in higher education as instructional tools, though it will inevitably be concerned to some extent with technical and administrative problems. It is a question of where we put the emphasis; and as this work is intended for the practising teacher it is his and the

students' immediate problems we wish to stress. We would also like to draw attention to the fact that, as in all other branches of education, the teachers who wish to use aids pertinently and effectively must first clarify their own ideas as to what they are aiming at (Beard, Healey and Holloway 1974). It is easy to say that this must be done: but experience shows that it is extremely difficult to do it; and this lack of clearly defined aims is one fruitful source of the clouds of misunderstanding in which our topic is swathed. If a teacher is able to say exactly what he is trying to do, a major step has been taken. It can then be decided what methods and machinery are necessary to achieve his goals and he is less likely to fall a victim to the pernicious disease of buying expensive equipment for the wrong reasons. This disease is more prevalent in British tertiary education than in the primary and secondary stages, because higher education is accustomed to a scale of expenditure well beyond that of the earlier stages. Luckily it has not yet reached the epidemic proportions which it frequently displays on the other side of the Atlantic, where massive under-employment of educational hardware is often reported by visitors such as Graves (1968a) and Perraton (in Perraton, Wade and Fox 1969) and where we understand there is even talk of a Congressional inquiry into the alarming situation that prevails in many schools in this respect. Let us hope we can learn from their example and make quite sure what we are doing before we commit too much of our scant resources to mere technical improvement that is of no conspicuous benefit to either staff or students. Much educational good can come of the proper use of what modern technology has to offer, but vast expenditure on machines is no guarantee of good education.

Most of these words were written ten years ago. Since then further consideration of the status and use of technical aids in higher education, and of the research and development that have been undertaken since the first edition of this work, have suggested some changes in emphasis from our previous account or have led us to elaborate in more detail on some of what was said then. On the whole, though, there has not been much significant alteration. What little there has been we now propose to consider.

Perhaps one of the most important points that has become increasingly apparent is that one great benefit of attempting to introduce technical aids in higher education is that teachers involved in such an exercise usually find themselves compelled to rethink their teaching more systematically. Like imbibing certain medicines, this is not always a process greeted initially with pleasure but its long-term effects should be good. It involves, in one way or another, the application of the ideas of systems analysis. Within the realm of education such an analysis is often, though not necessarily, spelled out in some form of structured or programmed learning. Faced with a teaching problem, the teacher may not at first think of it in this way. He may feel he'd like to use a particular technical aid, be led on from this thought to analyse why he wants it and, as a result of his reasoning, find that he does not need that specific aid at all. Nevertheless he now has a much clearer idea of the real nature of his problem and the best way to solve it. The technical aid, or, rather, the idea of using it, has thus acted as a catalyst rather than a substantive component of a beneficial reaction – but the reaction would not have taken place had the notion of the technical aid and its employment not floated into someone's consciousness. The full finicky rigours of programmed learning are not usually necessary in higher education, but the climate of thought from which such rigours arise is a vital ingredient in improvement.

The use of programming techniques is recommended and exemplified in a book by Ornstein et al (1971) Programmed Instruction and Educational Technology in the Language Teaching Field. To identify the process under consideration they suggest the adoption of a term originally proposed by Carroll: 'Designed learning'. This avoids what they feel may be some of the bad associations of the term programmed learning, but emphasizes the purposive element. 'Designed learning requires the orchestration of all we know about learning, about the requirements of the subject matter or skill to be learned, and about characteristics of learners, into a program or programs of instruction.' (Carroll 1968.) Even if not much measurable benefit to students results, the systematic approach allows for reasonable identification of where things have gone wrong. Mistakes can be profited from, rather than blindly repeated. If improvement does occur, much of it may well stem, as in other fields, from increasingly specific statements of what is to be learned by the students.

Some authors have tended to agonize over the question of fitting methods exactly to particular students, and the whole idea of 'personalizing' learning has become more prominent. There is probably a bit of a will-o-the-wisp being pursued here if you go about it the wrong way. Education is not a finely geared and meticulously engineered process, and by the time you have pinned down a student's learning pattern and matched it in great detail with a particular teaching package, the intended learner will already be an old man. The more hopeful approach is to provide a variety of different learning pathways, plus readily available help from sympathetic and flexible teachers.

Thus Elton et al (1971) report on eight experiments carried out on parts of the preliminary course in engineering, mathematics and science at Surrey University with about 180 first-year students. The experiments involved taped lectures (for library use); tape-slide presentations to replace lectures; teaching carrels in the library with technical aids; lecture-demonstrations on videotape, plus a programmed script; and programmed compared with non-programmed lectures. In summarizing the evidence from these experiments they came to this conclusion:

> 'The innovations have generally been successful in promoting more learning; but student preferences vary greatly as between methods. Staff and students like lectures, and it is therefore easier to provide adjuncts to lectures than to provide replacements.'

These two sentences encapsulate neatly certain basic truths regarding the current scene, and we shall return to the second one later. The advantages of variety and multiple provision have been demonstrated in more than one trial; though many people still hanker after the one true way which it is felt must exist.

This feeling is often intensified to the point where teachers are extremely reluctant to use teaching materials other than those produced locally for strictly local consumption. Bartlett (1970) presents such a view. Teachers feel, quite rightly, that their students and their courses are unique; but, with due respect to all those who say this (and with apologies for the solecism), they are not as unique as all that, and AV materials produced in one place may well be equally useful elsewhere. This idea has long been accepted for text books (much as we all long to write our own), but resistance is often greater in the newer fields. Engel et al (1972) tested

at Otago, New Zealand, materials originally produced at University College, London, for the use of medical students in the preclinical part of their courses. There were four tape recordings, two 8 mm films, two scripts (matching two of the tapes), and four illustrated booklets. Trials with 122 students showed that they worked just as well on the other side of the world as in England. Such a finding probably reflects two aspects of the educational scene already mentioned: 1 Careful thought about the construction of material is bound to give a reasonably effective product; 2 The teaching-learning process is not a minutely adjusted one.

Certainly there is plenty of evidence that technical aids work, and, if rightly handled, have a part to play in many learning environments. What is equally clear is that, overall, it is difficult to produce any obvious or massive improvement by their use in student learning as displayed in examinations. Jamison et al (1974) in their thorough review of 'The effectiveness of alternative instructional media' come back to this point more than once (and, incidentally, provide a useful bibliography). They do also conclude, however, that though learning levels may not be raised, 'productivity' can be increased. What this usually means is that thorough analysis and proper attention to students' needs enable the same amount of material to be absorbed more efficiently in a shorter time. (See also Engel et al 1972, and Campeau 1974.) Whether the students and teachers would tolerate this higher level of productivity and efficiency if applied throughout a whole educational system is not certain, but in small segments it is usually welcomed as an improvement on what has gone before. (The fact that a new method is felt to be better, or can be proved to be so, doesn't necessarily mean that staff and students want more of it: there is a lot of inertia in educational systems (Flood Page 1971).) Jamison et al also argue that we have not had enough in the way of conclusive testing of AV techniques to be able to make fair comparisons with the traditional ways of operating. The situation is changing, however, with the development of such systems as that of the Open University (see below).

What is not changing much is the attitude of teachers towards the use of hardware or to innovation of any kind. There has perhaps been a little movement in the last ten years on this front in Great Britain, concomitant with the setting up of service units in many universities to aid professional staff development. Certainly the problem is more out in the open now, but whether we are now at the top of the tide, or whether it is still rising is not clear. Cowan (1974), in an astringent piece in the Times Higher Education Supplement, is not hopeful:

> 'It is time for educational technologists to realize that they are making a minimal impact in higher education. Despite a vast expenditure of UGC funds on audio-visual units, backed by the forceful promotion of workshops for lectures and the appointment of specialists with a full-time commitment to develop modern methods of education, progress is still difficult to discern.... Most universities now pay lip service to the ideal of in-service training by offering brief courses which at least introduce the new ideas, even if they cannot spare time to offer a proper training in them. But the proportion of lecturers who emerge from these workshops and courses to participate actively in the struggle for change and improvement is still pitifully small.'

After detailing many of the sources of resistance and expatiating on its nature he concludes pessimistically:

> 'It is hardly overstating the case to maintain that the disadvantages attendant on the adoption of educational technology are sufficiently grave that it can only be commended meantime to those for whom teaching and education is the primary consideration.* The future initiation of curriculum and teaching developments should therefore be undertaken in the knowledge that this will continue to be a minority interest among academics, and that the existence of the system of higher education will continue to obstruct any attempt to initiate movement in a new direction. As a result it may be that it will prove best in the long run to concentrate attention (and financial support) on "pockets" of high activity, and to abandon the present unsuccessful attempt to enlighten the academic multitudes, without having much to offer in the way of authoritative and experienced leadership, or examples in service to emulate, or promotion prospects in recompense.'

He may well be right in what he says; but his cri de coeur is couched in traditional, unmeasured fashion. It may appeal to our emotions, but hardly helps us to see our way forward. Zeckhauser (1972) also took a look at the media in higher education and agreed with Oettinger (1969) that technology had been oversold, pointing to the confusion of the hardware market. She considered four factors which in her view worked against educational technology: the inadequate support provided by software, the generally unresponsive educational system, the impersonal character of mechanized instruction and the lack of an adequate supporting theory. Likewise, Holroyde (1971), in discussing educational technology, reminds us that 'Its resources can be used all too easily just to extend, by electronic or other means, existing methods of teaching, whereas research tends to establish that students respond more readily to materials that open up new concepts of learning rather than those which simply appear to encapsulate old approaches.'

Another complication which has added to the confusion and uncertainty in this area is the phrase 'educational technology' itself. To the ordinary teacher the phrase usually means hardware - what we in this book call technical aids - but to the devoted educational technologists themselves the phrase tends to mean the whole process of teaching and learning and the way you go about it. Readers of such books, for instance, as Brook and Race (1978) and Hartley and Davies (1978) might find it hard to know what the term signifies, so wide is the variety of activity described and analysed. Indeed, Davies, in his introduction to the second book referred to, seems almost to glory in this profuse confusion. Such a process of meaning extension is well known in the history of language, but it seems a pity that it should happen so often and so fast to widely used terms in the study of higher education. 'Workshop' is another word that lately seems to be suffering a similar fate - its meaning is extending so much that it almost becomes meaningless.

A more hopeful, more scientific approach is exemplified in a paper by Hopper et al (1974) on 'Staff attitudes to instructional innovation in higher education'. They tried to analyse, in one particular case, just how teachers did regard innovation, and it was not a simple matter of polarization for and against. The particular topic they selected was attitudes towards programmed instruction (PI),

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* Just think what this implies about teachers in higher education! CFP

which, as we indicated earlier, is in some senses a key issue. They administered questionnaires to, and interviewed, 30 staff members from one college: a stratified random sample from the departments of statistics, government, and economics, very similar in composition to Halsey and Trow's (1971) national sample. As a result of the testing they classified the staff under various heads, as Elitist or Expansionist, Teacher or Researcher, Local or Cosmopolitan. They also obtained staff ages, self-ratings of their political position, and a measure of rigidity. They ranked staff attitudes towards PI on a seven-point scale and compared this ranking with their subjects' positions in the categories mentioned above. They found a complex situation. Members of the statistics department were more favourably disposed towards PI than economics teachers, and these again more than those in government. Whether advanced or introductory courses were being taught was not significant. Expansionists were more favourable than Elitists, but Teachers and Researchers were about the same, as were Locals and Cosmopolitans, Rigids and Flexibles, young and old, and junior and senior teachers. The political centre was more favourable than either the left or right. 'In the government department, respondents were far more likely to favour PI when flexible and/or cosmopolitan. In contrast, economists were more likely to favour it when they were rigid and/or local; and statisticians when they were rigid, but not necessarily either local or cosmopolitan.' Perhaps their sample was too small, perhaps their categories and tests were not the best for the job (as they acknowledge), perhaps all they are saying is that staff, like students, are all individuals; but at least such an attempt makes a genuine, scientific contribution to the debate. Work of this kind can be used as a starting point for other tries at categorizing and elucidating.

Even here, however, it was only staff attitudes that were being gauged. How attitudes might have been expressed in action was not tested, and it is well known that there is no simple relationship between expressed attitude and actually doing anything. Collier et al (1971) and Gilbert (1973) both surveyed colleges of education, and commented on the cautious and doubtful attitudes of staff towards the use of technical aids. On the other hand, Clarke (1973) describes an ambitious programme at Dundee, involving a significant amount of self-instruction, and Leedham (1973a) describes the progress from programmed learning to educational technology at Loughborough. Other colleges have made more modest provision; but in many cases there is now a member of staff with full-time responsibility for work in this area.

Grayson (1974) in a brief, perceptive review of 'Trends in engineering instruction in the seventies' specifically considers this problem of what action is most likely on the hardware front in the coming years. He concludes: 'The use of... a hardware delivery system to provide off-campus opportunities for education, particularly at the graduate level, will continue to increase. In on-campus settings, however, it will not be used to a significant degree to deliver instruction, but will be employed primarily in supplementary ways or as aids to classroom teachers.'

This seems to us probably a true prediction, and it ties in with the conclusion of Elton et al (1971) quoted earlier. The Open University is a case in point. Hardware has to be used; the system would fail without it; but in all more traditional institutions people prefer the more human interactions, despite their numerous shortcomings. Daniel and Umbriaco (1974) explore the problems that arise when

an attempt is made to join a new Open University type system to an ordinary system, and point out one of the human snags: 'An Open-University-Level-Learning-System which is embedded in a conventional university tends to give too much weight to the opinions of the staff on campus when a course is under way. Corrective measures based on these opinions often upset procedures which the students found quite satisfactory.' Even in the Open University itself there is a constant demand from students for more tutorial contact, and one understands that many staff, particularly at the centre of this vast enterprise, would like to revert to a more accustomed role. How much this is just indolent inertia, as was suggested earlier, or how much it represents something more valuable and worth retaining is difficult to determine. One thing the Open University has demonstrated quite conclusively, however - and it is worth thinking about - is that large numbers of students can learn as much by means of hardware and books as those who have the unremitting attention of teachers. They may not like the process so much, but they can learn. We hope this fact will provoke teachers to ponder more seriously their own role. As we said earlier: such thinking is often one of the chief benefits of attempts to use technical aids. Harris (1971) put it neatly: 'It is all largely a matter of attitude, a readiness to re-think one's responsibilities as a teacher, as a stimulant and organizer of individual learning. Yet there are also the practical problems of supply of materials, and time, cost and convenience.... How far, one wonders, is use governed by availability or availability by use?'

One major problem that we have not considered is 'cost-effectiveness' - a topic that has very uneasy connections with education. You can find some parts of the system that are easily costed and others where the idea of costing is almost impossible to apply. How all these disparate elements can be added together is another headache. Caffarella (1975) refers to the lack of data in this area: only 32 of 300 references had relevant empirical or quantitative data. McAleese (1977) lists 90 titles. Those interested should consult Layard and Oatey (1973), Rowe (1975), Zeckhauser (1972), and particularly the recent works of Fielden and Pearson which give admirable analyses of the complexities of costing in education (Fielden 1978; Pearson 1977; Fielden and Pearson 1978).

There are other factors regarding the place of technical aids in the higher educational process which we shall try to analyse later considering in some detail the research that has been done on particular pieces of apparatus or particular uses of sounds and pictures. To this detailed research we now turn. While most of this is not really 'hard' research with all relevant variables carefully controlled, we have in all cases tried to report the hardest available and to indicate where the soft spots are.

The presentation of still pictures of many kinds is probably the most common aid to the written or spoken word. Some of the presentations are of a traditional kind, but a number of modern devices and media are available for this purpose. The pictures can be either drawings, diagrams, charts and other static non-projected material, or projected transparencies - slides, film-strips, material for the overhead projector. In all cases the essential nature of the presentation is the same as far as the student is concerned: what he sees is something silent and fixed, one frame at a time. Research into the instructional effectiveness of this sort of thing is not plentiful, but all tends to point in the same direction: still pictures on their own are neither educationally good nor educationally bad. Their impact depends on their proper relationship to the other factors in the context in which they are being used. Thus, in an experiment involving 231 students, soldiers and airmen, M.D. Vernon (1946) found that graphic material does not necessarily convey clearer information than verbal or mathematical statements and may confuse learners who are inexperienced in handling it. Level of intelligence seems to be an important factor in determining amount of learning from visual presentation of factual data.

Several researchers have concluded that the verbal accompaniment to the visual material, whether in the form of captions and title or of spoken commentary, must be carefully adapted to the listeners if they are to derive benefit from it. Thus Hall (1950) experimented with giving graduates the task of reproducing drawings or printed passages which were accompanied with varying verbal titles or no title at all. They were only given a brief sight of the original (a situation not uncommon in learning), and it became clear that the exact nature of a caption could have an important effect not only on how much was remembered, but also on what was remembered. He found that the nature of the reproductions varied with the verbal framework, and that the intelligence and attitudes of his subjects were also important. Laner (1956) studied the effect of teaching a manual task to young adults, either by means of a film or by still pictures. He concluded that in a lesson given mainly by pictorial means the degree of understanding displayed by the learners was chiefly controlled by the verbal exposition that accompanied the pictures. M.D. Vernon (1950, 1952, 1953a, b, and c, 1954a and b, 1964), in a series of investigations chiefly with pupils in the upper forms of grammar schools, emphasized the necessity for clarity and precision of words, either spoken or written, if the sometimes powerful but often vague impact of pictures, charts, and graphs, is to play a proper part in instruction. It is suggested (Center for Research on Learning and Teaching 1967) that research into the uses of audio-visual aids might well be most valuably concerned with fundamental psychological and physiological aspects of the learning process; and because still pictures are extremely easy to manipulate they might be a preferred means for investigations of this kind.

There is now a very large selection available of materials for producing still graphic displays. A catalogue published by the Educational Foundation for Visual Aids (1975) exemplifies this profusion, and demonstrates how much is now available for the teacher who is not satisfied with traditional equipment. It lists over 75 main suppliers and manufacturers, and hundreds of different items. These include a bewildering variety of pens, pencils, coloured markers, paints, inks, crayons, chalks, rulers, pantographs, templates, stencils, papers, cardboard, transparent materials, letter sets, adhesives, plastic display boards, magnetic boards, peg boards, etc, etc. Projection machines are not proffered in such embarrassingly large numbers, but certainly there are enough to make choice a daunting prospect for any teacher who takes it seriously. Fortunately the National Centre for Visual Aids is available for consultation on this awkward matter, local audio-visual or other units can also be helpful, and experimentation by the teacher himself need not be expensive in either time or money.

Projectors for slides and film-strips have been in familiar use for many years and often seem to be taken for granted. There is however very little research evidence as to their effectiveness at any level of education. McTeer (1977) found that the use of 850 negative slides in a foundations of education course brought about greater learning than in classes taught without slides, and students liked the technique. Maddox and Loughran (1977) also used a build-up form of presentation and compared this with the use of already completed slides in geography. Both methods were equally effective but over two-thirds of the students preferred the build-up presentation, although build-up of tables was not liked. Among the reasons for preference was the simplification of fairly complex material, time available for making notes, and the possibility of learning in time with the progressive presentation. The minority in favour of completed slides wished to have the whole picture and then a build-up sequence. Hartley and Cameron (1967) found that students tended not to note material presented as slides; they suggest that teachers should say when notes are to be made and allow time for this to be done accurately. Hartley and Fuller (1971) followed this up and compared the use of slides with a blackboard presentation. They found that students liked the slides but learnt better from the latter. Partly this seemed to be because the slides were shown too rapidly and the students didn't have time to make proper use of them. The researchers concluded that it would be more efficient to present the content of the slides on handouts. Stanton (1976) repeated the experiment in Australia and found a difference in favour of the blackboard which led him to conclude: 'The results give considerable comfort to the chalk and talk brigade.'

Two reports of systematic use of lap-dissolve or dual-fade projection, in chemistry (Happ and Snyder 1977) and in physics (Allen 1975), both show improved student performance, attitudes and motivation; students preferred this form of presentation to the use of other media. For the chemistry series, 10-15 slides of moderate complexity called for a total of 2-6 hours of preparation and production time and there was a need for five times as many slides as for single projector presentation. Dwyer (1972) summarizes 27 of his own studies. For instance he compared black and white and coloured illustrations in physiology instruction, not only varying the major type of illustration but also varying the style of drawing (Dwyer 1971). He used 262 students randomly divided into nine groups, and his post-tests involved drawing, identification of parts of the heart, knowledge of concepts and symbols and comprehension of processes. He found that success in

some of the post-tests had significant links with particular kinds of picture presentation - eg detailed, shaded drawings in colour were best for identification of parts.

Such inquiries prompt further reflection and questions. Why do many teachers, for instance, persist in using slides in the dark, when students cannot take notes, or whip them through so fast that the learners have no time to absorb the information they contain? What do they want the students to take away with them: a confused blur or a precise image? As frequently used, slides may often only provide the former, and a handout may indeed do the job better. The teacher should always remember that the students don't know the slides nearly as well as he does, and so the specific style of the picture may be much more important than he thinks in helping to put over the points he wishes to emphasize. Such points do not leap from the screen into the students' eyes and brain with the rapidity and selectivity that the teacher may fondly imagine.

The overhead projector, though not new, has in the past ten years or so found rapid favour with teachers, and it is a familiar sight in most lecture rooms. It is possible to employ simple, extempore transparencies or quite elaborate ones, often professionally prepared (Vincent 1965). This projector may be thought of as the modern equivalent of the blackboard, extending its scope, and its growing popularity may also be linked with Seymour's finding in 1937 that dark lettering displayed on a light-coloured board is more easily seen by students than the traditional white chalk on a dark board. Foster (1968) tried out something rather like Seymour and confirmed his findings; thus an overhead projector display is more likely to be better seen than a blackboard one. It may be suggested that there are a number of other reasons for its increasing use, including its lack of technical complexity, its cleanliness compared with chalk, its ease of transport, adaptability to different teachers' styles, and the fact that the teacher faces his class while using it. (Those who still cling to chalk may like to know that a dustless variety has been available for many years.)

Seymour's research was reported in 1937; the overhead projector came into wide use thirty years later. A time-span of this order from research finding to large-scale practical implementation is perhaps something we may hope to improve on in today's climate of more rapid change, though the lack of contact between practising teachers and educational research findings has been documented (Georgiades 1968; Johnson 1966; Gilbert J.K. et al 1979), and does not give much grounds for optimism. In the case of the overhead projector, development and use have gone ahead on a significant scale with little reference to research (which is in any case almost non-existent) and the reasons why things have happened this way are worth pondering on. (They are probably not far to seek and we will refer to them later.)

No reports have been published of research carried out in Britain. In the United States, use of the overhead projector has resulted in gains in tests of learning in courses in civil engineering over a control group taught with textbook illustrations (Jenkins 1977) or by a traditional lecture-discussion approach (Chance 1960). In the latter investigation 200 transparencies and 800 overlays were used; there was an average saving of fifteen minutes per class and the students had an overwhelming preference for the use of transparencies. From Israel there is a report of an

experiment with students taking courses in hydrology and geometry, taught either with an overhead projector (OP) or with the blackboard during a period of fourteen weeks (Perlsberg and Resh 1967). The OP group in geometry learnt more than the non-OP group, but in hydrology no differences were observed. A majority of students favoured the use of this apparatus, but there was no correlation between attitude and attainment. As in many other experiments of this type one may suspect that non-reported variables were among the important determinants of the differences between geometry and hydrology learning; but one can at least draw the conclusion that the overhead projector is unlikely to have a negative effect on student learning. This was also noted in a report of the use of the overhead projector in the teaching of an introductory course in psychology to a large group (Taylor 1974). Superiority in attitude and achievement did not however appear on re-testing after six months, and a caution is given about generalization of the findings of the experiment to other settings and subjects.

Common experience suggests that if learning is intended insufficient thought is often given to the suitability of material for projection or to viewing arrangements: use of colour, optimum distances of viewers from the screen, size and style of lettering, all need to be considered. What is legible on paper - pictures, charts, diagrams and tables - may be invisible or incomprehensible when projected as a slide. Eastman Kodak (1975) provides a comprehensive guide to the planning and production of slide programmes and J.M. Adams (1971) and S. Adams et al (1965) give design recommendations for overhead projector transparencies.

SUMMARY

1 Though they are widely used, research evidence as to the precise functions of still pictures in higher education is not plentiful.

2 They must be reasonably integrated with other elements aiming at a proper instructional objective if their possibly powerful impact is to be well harnessed to learning.

3 They largely depend for their instructional effects on their precise mode of use and may not always be as effective as the teacher thinks.

4 If not geared to the learners' stage of knowledge and development, or if not well matched with words (either spoken or written) they may produce confusion and retard rather than advance learning.

5 On the other hand they give depth and location to words, and thus help to anchor them in the mind. (As many teachers in higher education have arrived at their present position by a predominantly verbal route this point is important.)

6 As still pictures are easy to manipulate and available in a large variety of forms it is suggested that they may be best used for research into some of the precise physiological and psychological processes involved in learning.

Studies of the educational value of moving pictures have usually been conducted in terms of a specific type of machine, or of a single medium (film or television), and not in terms of what the student sees, though Mundy (1962) has come to the conclusion that there is no significant difference between the two media as teaching aids. His research is supported by the considered transatlantic judgement of McKeachie (1966), who discusses his findings in terms of films but sees them as equally applicable to television. In a lengthy survey of relevant work in The New Media in Higher Education he finds that:

1 Students learn from films as much as from a poor teacher.

2 Such learning is not confined to factual details, but can include concepts and attitudes.

3 A badly organized film may make a better impact if given good titling and commentary.

4 Repeating a film increases learning for less intelligent students.

5 Students who are used to having instructional films learn more than do those to whom they are a novelty.

6 Pictures are more effective than words as stimuli in rote-learning tasks such as those involved in acquiring a foreign language.

7 Learning is improved if film-watching is not a passive process on the part of the students; but the precise nature of student activity needs careful consideration.

Hoban and van Ormer (1950) also offer some conclusions, as the result of a critical evaluation of a large number of documents recounting the experimental use of instructional films in the USA but equally relevant to television.

1 Factual knowledge, motor skills, attitudes, opinions and motivation can all be learnt from films, used in different ways.

2 Films in combination with other instructional material are better than either alone, both for immediate and retained learning.

3 Films can stimulate other learning activities and facilitate problem solving.

4 Films are equivalent to a good instructor in communicating facts or demonstrating procedures (cf 1 in McKeachie's list).

5 Films are of greatest influence when their content reinforces and extends previous knowledge, attitudes and motivation. They are of least influence when previous knowledge is inadequate, and when the film content is antagonistic or contrary to existing attitudes and motivation.

6 Colour has no particular advantage over black and white, unless the colour itself is a necessary part of what is to be taught. (This finding has been confirmed by Kanner (1968) in a careful review of the evidence on the effectiveness of colour in instructional television. More recently (1979), Johnson and Robertson found that this conclusion still holds: use of colour resulted in no significant gain in learning although it may be a desirable factor in producing materials which appeal to aesthetic senses.)

7 The instructional effect of a film depends little on high technical finish and slick production; but too much sound with the pictures can have a detrimental effect.

8 Response to moving pictures is selective in terms of the familiarity and significance to the audience of the pictorial context in which the action takes place.

9 Response to films is greatest when the audience can identify itself with the chief characters, when the audience is addressed directly; and when they can see what is happening as though the camera's eye were their own, if they are learning a manual skill.

10 Normal basic educational principles apply to films: ie learning is greatest if the pace is geared to the students, if a brief summary of the subject is given at the start and finish, if there is proper follow-up and reasonable repetition within the film, if there is time for student participation during or following the showing, and if students and teachers have immediate feedback as to what has been learnt correctly.

11 The character of the person showing the film affects the amount learnt from it.

In a later review of research Allen (1971) concludes that 'An instructional film of good content and technical quality, properly utilised in the instructional-learning plan to achieve an appropriate learning goal, will achieve that goal with equal effectiveness in less time and at substantially lower cost than conventional or traditional methods.'

In both McKeachie's list and that of Hoban and van Ormer the words TV programme or videotape can usually be substituted for 'films' and the statements remain true, provided one is referring to material of equal quality. This idea runs counter to what many single-medium enthusiasts would like to believe; but it has been further exemplified in an extensive study by Balin and others (1970). Over a three-year period they made a comparative evaluation of colour television, black and white television, colour film, and instruction without such visual aids, to teach medical students the endoscopic examination of certain organs of the body. The prior assumption was that, as visual identification of the material to be taught was vital, coloured moving pictures were bound to be more effective; but over the

three years there were no significant differences in learning among the four groups of students tested, and the authors conclude that the decision as to whether to use television or films, colour or black and white, is one that depends on considerations other than those of teaching effectiveness. Perhaps the mesh of their analysis is not fine enough to catch such differences as do exist, and there may be long-term differences not yet measurable or even directly observable.

For instance: Perraton has suggested (personal communication) that there are differences in presentation style (and therefore in effect?) between TV and films because of their disparate ancestry. Modern sound films are the descendants of silent films, and the emphasis in this line is on the visual elements. TV, on the other hand, is the heir to radio, and has developed from a tradition in which the spoken element is all important. Producers, writers, technicians and viewers therefore have different sets of attitudes and expectations relating to these different media and approach them in different ways. Also, outside an educational context, the circumstances in which people are accustomed to viewing films are quite other than those in which they see TV, and these differences must have some effect. Such subtleties and differentiations as these may not seem of great importance to the teacher in the present state of the art, but if we do ever reach a stage in which really comprehensive preliminary analysis and tailor-made presentations become the rule then such considerations as these may need to be given greater weight. Berry and Unwin (1975) and Unwin (1979) list respectively 60 and 45 published accounts of research relating to production and audience and viewing variables in educational film and television. What emerges is that the present state of knowledge gives little help to media designers but there are convincing arguments that production techniques can influence learning. Up to date, however, those who have experimented with these visual aids have usually tended to carry out their research in terms of a specific medium, either TV or film; and we therefore propose to summarize the work on this basis, and not enter further into the relative merits of the two systems.

FILMS

Most of the few British projects concerning films come to neutral or favourable conclusions as to their instructional merit. An experiment by Hughes, Collard and Cardew (1953) showed that a silent colour film could teach medical students a technical procedure (How to Inoculate a Plate) as well as a live demonstration could, while a film on 'The Carotid Sinus' proved both popular and effective as a teaching aid with a similar group (Steinberg and Lewis 1951). James (1967) found that films can help to improve the reading speeds of students at technical-teacher training colleges, though Poulton (1961) concluded that the films themselves are probably not an essential ingredient of the process. Kenshole (1967, 1968) found they could be an effective means of revision for students of electrical engineering, though their efficiency as an introductory teaching technique was not proven. Exactly which elements are important in making an effective instructional film is not yet clear, though Laner (1955) found that realistic representation does not appear to be essential. A film may not be in a high class technically, and yet students learn well from it. P. E. Vernon (1946) came to the conclusion that in some circumstances films or film-strips can compensate for weak instructors, while Toms (1968) found that films from the archives of the Imperial War Museum

were both helpful and stimulating to discussions and written work in a college of education for mature students. Pearson and Jepson (1969) used 8 mm film loops to teach detailed technical operations to dental students. Assessment of the process showed that the film loops made the techniques clearer than did a human demonstrator; but nevertheless most students still wanted to have the human demonstration first, and to use the loops for revision and reference.

It is worth noting that in the case of films much discussion has centred on the comparative merits of 16 mm and 8 mm. Technical development is proceeding rapidly at present, and it is difficult to foresee exactly what choice teachers will eventually be offered in this area. One must therefore be cautious about making dogmatic pronouncements about relative merits at this stage. The 16 mm format is at present normally used for longer films, especially if they employ sound and colour, while the 8 mm is used for short displays, often in black and white, without sound, and using projectors that accept easily-handled continuous-play cassettes. The arguments about the good and bad points of these two different sizes of film are often administrative and technical, and not closely concerned with instructional impact on the student, who is not really bothered, provided that the material offered meets his learning needs. However, when teachers are lacking immediate technical assistance, questions of ease of handling, repair facilities, availability of spares, etc, may be the most significant features in the analysis when deciding which format to use.

Instructional films continue to be produced in large numbers and numerous catalogues and lists are available for the teacher to choose from. Just how good they are as teaching instruments is not easy to decide. The suspicion is that in most cases films are treated as light relief by both students and staff: they fill lecture time, but nobody expects much learning to take place in their presence. The folklore of education tends to locate them in the world of entertainment rather than that of more serious pursuits; but, as with most other technical aids, it depends what you do with them and how well integrated they are into the course structure.

In the pharmacology department at Bradford University, much time and expertise has been devoted to their employment, and investigations of the use both of short 8 mm and longer films have been undertaken (Foy and Leach 1969; Foy and McCurrie 1973). Eight mm colour sound film loops were particularly used with first-year undergraduates in the teaching of practical pharmacology and physiology. The students' feelings about the films were registered by means of a semantic differential, and the efficiency of films as teachers was compared with that of demonstrations. Free comment from the students was also solicited. It was shown that films were as good as demonstrations for teaching practical operation procedures, and the great majority of students were enthusiastic about their use, while recognizing clearly their good and bad points compared with traditional demonstrations. As regards longer films, seven specimens, varying in length from 19–35 minutes, were used as a routine part of the pharmacology course and shown to groups of 60–90 students. Pre-tests, post-tests and delayed post-tests showed that significantly large learning gains were made and retained. A replication without pre-tests (hypothesized to have biased the first results) gave a similar result. The authors stress the film's great capacity for magnifying small detail, its tirelessness compared with an instructor, and the facility for student re-run at any time.

A more general summary of the production and use of films in medical education, incorporating the results of research, was compiled by the International Working Party (1973). This volume makes explicit numerous questions, both theoretical and practical, about the use of films, and offers positive recommendations for future action. It deals briefly with general ideas about learning, and then has sections concerned with specific educational use, design, production, finance, distribution, assessment and availability. It concludes with a short discussion on the relationship between films and TV. Though concerned primarily with medical education, much of the work is useful to anyone thinking about the use of films in higher education.

Michalczyk (1976) describes the use of film for the teaching of a course in French civilization; course critiques showed that students learned to avoid generalizations and idealizations through use of the film medium integrated with lectures, reading, and written assignments. Details of other courses in French studies which use film extensively are given by Cousins (1976), and of those in German studies by Lamb (1976).

The problem of structuring affective objectives in an academic programme is faced in the production of 'trigger' films, high emotional impact vignettes, the purpose of which is to generate debate in the student. Fisch (1972) lists the essential features: the film must be short and to the point, the information should be limited, interesting side-issues should be avoided, the content must be realistic for the viewer, presentation should be simple, and points and issues should not be laboured, complete titles and other conventions are unnecessary, the film should be open-ended and offer many alternative choices to the viewer, and the end chosen for the film should be the optimal point for making discussion effective. A high level of acceptance by students is noted. Other descriptions are given by Powell (1977, 1978) and Boud and Pearson (1979).

TELEVISION

Barrington (1965) has summarized the findings of much of the work on educational television; and though his survey is not restricted to higher education his conclusions are worth giving in detail. He reports work done both with open-circuit TV (ie that which is offered by the BBC or ITV), and with the closed-circuit version, which has become the most common in higher education. His bag is therefore a mixed one, and much of what he summarizes relates to attempts to use TV in situations for which it was not altogether suitable. His conclusions must therefore be treated with caution. He found that there appears to be no significant difference in pupils' achievement whether they are subjected to television teaching or 'conventional' methods. Television lessons hold pupils' attention; but follow-up work is important. The optimum length of a lesson is about 25 minutes, and sound and visual elements must be well integrated. In closed-circuit television (CCTV) learners favour two-way communication between studio and classroom, but its absence does not affect achievement. Retention is much improved when pupils make active responses during a television lesson, and they favour TV lessons for direct instruction, rather than as background material. Less able pupils and those in junior schools tend to be enthusiastic about TV lessons, but attitudes become less favourable higher up the educational ladder. (It may be

suggested that this finding is connected with the amount of visual material stored in the learner's mind. In the primary stages of schooling there is plenty of storage space available and little resistance to new visual impressions. Indeed, there is often a strong need for them. As education progresses the learner's store grows to such an extent that over large areas he already feels amply supplied, so that he becomes much more selective and critical about what he is prepared to take in.)

Belson (1956) discovered that a BBC television series designed to teach French to adults produced an increase in viewer's knowledge of the language, but unfortunately heightened their fears about using the language and visiting France. A series given to adults on social works and administration (Hancock and Robinson 1966) appeared to generate much interest and stimulate various forms of work when combined with discussion groups. Perraton (1966) found that a television course linked with correspondence lessons was an acceptable and effective way of teaching older students; while Trenaman (1967) concluded that adults of all intellectual levels learned best from the concrete elements in programmes, with personification and dramatization becoming increasingly important at lower intellectual levels. This same study, and one of M.D. Vernon's (1953b), demonstrated the need for spoken and visual material to be closely linked to secure maximum effect: pictures hold the attention while what is to be learnt is fixed in the mind by words. On the other hand, if the visual element is too compulsively attractive in itself, learning of the verbal material decreases. (This finding prompts some speculation on the value of the female form in contemporary advertising.)

According to Wiltshire (1967) the economics and effectiveness of adult courses on economics were very similar whether traditional methods or open broadcast television were used, but the latter method was thought to reach many students not able to take part in ordinary evening classes. On the other hand, Harrington and Knoblett (1968) found that CCTV was less effective on a two-day introductory business course than lectures, though they considered it would be more economical if at least 350 students were being taught at once. Smith (1968) demonstrated that television teaching could produce a significant difference in student achievement in botany, but not in mathematics; but his report is not detailed enough to reveal the relevant variables.

In the teaching of skills TV appears to have considerable promise. A series of trials and experiments at Liverpool (James 1969) has shown the usefulness of CCTV as a feedback device to show their own performance to apprentices, trampoline learners, orchestral conductors, and social science workers. Richardson (1968) describes the use of a recorded TV programme shown in short excerpts as part of a carefully ordered sequence to teach experienced youth leaders interaction analysis, and he found the method effective. He also puts forward some hypotheses based on psychological premises as to why television has been so little used in education.

Several studies have been made of the use of CCTV to enable student teachers to observe either demonstration classes or their own performance (eg Northern Group of Colleges of Education 1965; Southern Group of Colleges of Education 1965). Dundee College of Education is one institution that looked into such problems over several years and issued a comprehensive report (Dundee College of

Education 1967). The researchers found that trainee teacher reactions to television tapes of their own performance were mixed. In particular, the weaker student teachers did not like the process. Children's activity sessions and many other types of behaviour could be effectively photographed, but reproduction of their voices presented technical problems as yet unsolved. Other technical troubles were numerous, though the presence of television equipment in the classroom seemed to have remarkably little disturbing effect on the children. The optimum length of a viewing session for learning from television was found to be 15 to 20 minutes.* Hale (1965) found that reactions to watching a demonstration class were mixed. Though individual children's actions could be clearly seen the student teachers found it difficult to judge the temper of the class as a whole. Another similar group gained a good grasp of the practical details of the demonstration and were inspired to do more educational project work: but there was no significant transfer of what was learnt in the demonstration to actual teaching situations in classroom (Mills 1966; Mills and Swindells 1964; Swindells 1966), and the student teachers felt the lack of personal contact and noted the extra time and effort needed to prepare for the special television sessions. Neale (1967) reports an experiment in which 257 student teachers were divided into four groups to be taught a particular classroom technique. One group saw an ordinary, live, classroom demonstration; the second saw the demonstration by direct CCTV; the third by recorded television; and the fourth was taught about the technique by a lecture. The ordinary demonstration roused the most favourable responses from the student teachers, and the lecture the least, with direct television second, and recorded television third; but their favourable or unfavourable responses to this particular segment of the course had no influence on the student-teachers' assessment of the course as a whole.

Foxall and Evans (1973) confirm favourable attitudes to the recording and discussion of lessons by students in training for work in further education institutions. Using these recordings subsequently with other groups however showed that students would prefer to have the opportunity for 'live' observation in the classroom, a finding which corresponds with that of Kitching (1967).

Medical education is another field where the uses of television have been studied extensively. Because of its value in certain hospital procedures, equipment has been readily available actually within or close to many medical schools, though not always in the most convenient form. Open television broadcasts to teach practising doctors new ideas and methods have also been tried, but not on a large scale or with conspicuous success (Association for the Study of Medical Education 1968; Engel and Meyrick 1969). The British Medical Association has established its own Department of Audio-Visual Communication. Smith et al (1966), in an experiment in which senior medical students were taught surgery with the aid of CCTV, found that the majority learnt better from television than from the previous procedures, and the improvement was most noticeable among those at either end of the achievement scale as defined by marks in their ordinary course examinations. Smith and Wyllie (1965) also reported that when first-year medical students

* Work at the TV Research and Training Unit at Goldsmiths' College suggests that five-minute 'shots' are probably the best (personal communication from the Director, Mr A. Gibson).

at Aberdeen were taught surgery by a mixture of conventional methods and television, more than half the class appeared to benefit from television, especially the average and less able. Eighty per cent of the students who made comments on the method approved of it, but those who commented were only a minority. The authors conclude that television is better as a part of a combined system than when used on its own. At Makerere, Cantrell and Craven (1969) taught a course on methods for the clinical examination of the nervous system to two groups: one by television and one by normal lectures. Subsequent tests showed no significant differences in learning between the groups, but the majority of the students preferred television chiefly because it enabled all students to see patients equally well. The authors stress four things in connection with television teaching:

1 The necessity for careful rehearsal.

2 The importance of clear viewing for the students.

3 The need for two-way contact between demonstrator and students.

4 The importance of other audio-visual aids, diagrams, photographs, etc, being well co-ordinated with television.

At Edinburgh University videotapes have been used to teach social medicine (Maclean 1969). Three tapes were prepared to be used as the starting point for discussions on 'Social Inadequates', 'Mental Defectives', and 'Disabled Women in the Community', and all did their job well; but Maclean reports an interesting and unexpected effect. The first two tapes had been prepared by the staff, and the third by twelve students, who also took part in the actual interviews that were being screened. This last student-prepared tape was notably the most effective in promoting immediate and relevant discussion, and students said less about the kind of technical deficiencies that they had carped at in the other two.

Elsewhere, videotapes have been used successfully in an integrated approach to physiology teaching in laboratory classes (Howland et al 1974), in teaching diagnostic radiology (Moss and McLachan 1976), in teaching child psychiatry (Forgotson and Sweeney 1977), and in improving clinical teaching (Cassie et al 1977). From these studies it emerges that there is greater efficiency in presentation in using videotapes, that preferred maximum length is about 30 minutes, that interview material can be sorted so as to be edited for multiple purposes, that highest scorers on tests are often most critical of the method; but that the method is generally well accepted.

Engineering is another subject that has been taught by television. Macfarlane Smith (1968) investigated the effect of a television course in engineering science on a large number of students, and found that while his experimental TV groups achieved no better examination results than the controls, they appeared to show a rather more favourable attitude to the course than did those taught by the usual methods. Craig (1968) describes how one complete course of study in electrical engineering was presented by CCTV accompanied by printed handouts, and backed up by tutorial sessions. He found that the procedure was sufficiently acceptable for further courses to be planned, but like other researchers he emphasizes the fact that television must be well integrated with the other elements in an instruc-

tional system. He also noted that technical imperfections in the presentation were unimportant if the material being screened was of good quality. Coney et al (1969) got rather mixed reactions in an engineering course at Leeds University. If TV was doing a job that could not easily be done in any other way the students were quite willing to accept it. They found it useful for showing them complex laboratory tests and procedures immediately before they themselves had to undertake such operations; but they disliked straightforward lectures in this medium. Cowan (1969) found videotapes useful for stimulating discussion rather than teaching facts in thermodynamics.

After consultation between teachers of fifteen universities two television tapes on 'Introductory Statistics for Social Science Undergraduates' were prepared and favourably received by about 80 teachers (University TV Newsletter 1969). This favourable opinion, however, did not make more than half the viewers willing to use the tapes; and even the half who were willing did not usually want them in their entirety, but wished to integrate selections into their own courses.

An investigation of the possibilities of using television for linking departments at different universities so that lectures and discussions could be shared concluded that the quality of the teachers, rather than the technical apparatus, was the overriding consideration in how much students learned from the experimental seminars (Laslett 1964; Perraton, Wade and Fox 1969). Nevertheless, students liked the idea of such an interchange because it made a great number of good teachers available to them and saved the time required for journeys to see new equipment or special experimental apparatus. The administrative and financial obstacles to doing this kind of thing 'live' were such that it was considered that the process could best be carried on by means of recorded material, with a centralized information and library service such as the late Inter-University Research Unit pioneered at Cambridge.

At a more general level Cazeneuve and Pagès (1966) studied the changes in relationship between students and teachers when CCTV was introduced in two departments of the University of Paris and one department of the University of Nanterre. Their inquiry revealed effects which are familiar during the mechanization of a profession, including increased specialization of functions and problems of coordination and hierarchical organization: ie each teacher's tasks become fewer in number and more clearly defined; all teachers have to know more exactly what their colleagues are doing; and the chain of command and decision-taking within the institution has to be more precisely decided on and adhered to. The one-way character of most CCTV was also discovered to be having a definitely adverse effect on staff/student interaction, especially where no attempt was made to compensate by other means for the loss of contact between teachers and students. Similar points to these are among those listed as meriting research by Holroyde (1966) in a paper concerned specifically with research into the evaluation of educational TV. The list which he proposes for consideration is as follows:

1 What are the ideal viewing conditions for lecture programmes at university level? Taking a class of 60-70 students as average, is learning and attention best served by assembling them in one lecture theatre with two or three monitor screens, or in separate rooms, each with one screen, and each holding 25-30 students?

2 What is the attention span of 18-20 year-olds when learning through television: 60 minutes, 40, 30?

3 What special arrangements should be incorporated in presentation if there is a need for students to take notes? Could this be done by alterations in the pace of presentation, or, for instance, by allowing for a slow recapitulation of significant verbal or visual displays at the end?

4 In subjects which demand a considerable inclusion of visual material how complete is the degree of recall afterwards? To what extent is a second showing desirable, so that the first allows a student to grasp the total concept, while the second enables him to learn details?

5 Are there new laws to be discovered about the variable methods of presenting information on the screen at this level of education? To what extent is it desirable to show the lecturer? When, and how often, does visual material need support by (a) the spoken word; or by (b) the written word in caption or diagram form?

6 Is it true that the total presentation of a course by television makes an increase in tutorials or seminars necessary?

7 To what extent should the production of a teaching programme in a university attempt to find a style which meets the psychological need of the audience, and how could this style affect the way the subject material is framed and phrased?

As with the catalogues of American findings on film already quoted (McKeachie 1966; Hoban and van Ormer 1950) it is clear that the questions posed here could be put with regard to any means of projecting moving pictures. They are not unique to television, and some are perhaps of a trivial nature; but any attempt to ask detailed and practical questions is worth pursuing. The grain will inevitably be sorted from the chaff if the process is honestly and openly continued.

It remains true that television is one of the most studied aspects of AV aids in education. Partly this may be because of a vaguely felt social pressure - TV is such a common feature of life that everyone takes it for granted, and therefore it is somehow assumed that it must have some sort of a place in education. Partly this may be because it is a costly aid, and the expenditure may trouble some consciences if use is negligible or ill-considered. Perhaps it's just the Everest reason: 'Because it's there!' Whatever the cause, it continues to attract a lot of attention, and recent technical developments may increase the flow of use and investigations, though, as Harris and Austwick (1973) show (in 'TV or not TV') it need not be an automatic first choice among the media.

What is the best way to employ the apparatus still remains an open question. McQuail (in Halloran 1970) maintains that its place lies firmly in large-scale operations, like the Open University. He considers that TV will make its maximum contribution to solving educational problems in a situation where course content and examinations are standardized, where there is central planning of teaching and common levels of progress through a course, and where there is a

high degree of specialization of staff function. In other words: the proper place of technical aids is not within the ordinary classroom. Not everyone would agree, and even McQuail himself admits there are difficulties in applying such theoretical ideas at a practical level. At the local level there are certainly those who have found TV useful: Smith (1974), for example, has summed up 20 years of using TV to teach some aspects of surgery to medical students at Aberdeen University. Various groups of students were tested over a five-year period on their surgical knowledge and the test results carefully analysed. It became clear that all students could learn reasonably well from TV, and in most cases could reach the required level of knowledge faster by this method than by more traditional means. Jamison et al (1974) reach a similar conclusion from their extensive survey of research: they are not quite so sure about the gains in time, but there is no doubt that TV is a competent teacher. Robertson (1969) concluded much the same thing at the University of New South Wales, where TV has been used to take a load off staff shoulders in engineering since 1962.

A number of individuals have conducted trials in their own colleges and weighed up the pros and cons of the apparatus. Such a series of studies has been reported by Bradley (1970) at Portsmouth Polytechnic, using groups of up to 29 students learning electrical engineering. He noted the advantages of having to set up complex experiments only once, being able to mix a variety of materials into one presentation, being forced to make more systematic presentations, building up an instantly available store of videotapes, etc. He also, like others, cautions against lengthy presentations: no longer than 20 minutes for a survey, or 10 minutes for a detailed lesson; and advises that a good printed handout to accompany the showing may enable a student to get more benefit than merely presenting TV unaided. One comes back continually to the platitude that what matters is not so much the particular qualities of the medium as how it is built into a viable system.

Nevertheless plenty of effort has been devoted to analysing just what special effects can be hoped for from TV. Much thinking in this area has centred round the practice of microteaching and similar operations, in which individuals perform in front of the cameras in some specified role and then immediately have the opportunity of seeing their own performance and evaluating it, with or without an accompanying tutor. The widespread interest in microteaching is evidenced by the vast numbers of publications on it: one bibliography lists 467 references, some of them substantial (Malley and Clift 1974). A somewhat small number (355) appears in Falus and McAleese (1975) - itself an updated version of McAleese and Unwin (1973), listing 243, and that in turn an upgrading of McAleese and Unwin (1971). Hawkings (1970) surveyed its use in Australia, where 26 out of 35 teacher colleges had either installed CCTV or were thinking of doing so, though not all had got as far as including microteaching in the schedule of operations. He outlined both the virtues and the limitations of the technique as he saw it: 'Videotape can capture the detailed execution of teaching skills, but it may not reveal equally well other requisites for good teaching, such as enthusiasm and academic competence'. McKnight (1971) reviewed much of the evidence about the effectiveness of microteaching, particularly that concerned with analysing its various elements and their effects and interactions. He came to the conclusion that with properly organized feedback and modelling (see below) considerable beneficial changes could be demonstrated in student teacher behaviour, and that tutors were not needed to make the process work well. Nevertheless, as we have noted in

other learning programmes, the students felt happier when the tutor was present with the machines. McKnight also noted how widely the technique was being adopted in the USA where, in 1969, 53 per cent of teacher training programmes were using it.

There are two main streams in microteaching: the 'classic' Stanford model (Allen and Ryan 1969), and the 'minicourse' approach (Borg et al 1970). Brown (1975) deals in detail with a British approach to the classic technique and its application. The 'minicourse' is essentially an in-service, not a pre-service, technique. It is a self-contained package: films and tapes provide the basis for evaluation; and the trainees use a structured critique for evaluation, without a supervisor. Perrott et al (1975, 1976) report favourably on changes in teaching behaviour and teachers' reactions after a self-instructional course based on a Borg minicourse. Applebee (1976), however, in an evaluation of the project questions the component skills approach on grounds of misconceptualization and suggests that it may distort subsequent patterns of teaching. 'Mini-teaching' is an extension of the microteaching format which is thought to be more acceptable to those who do not have a behaviourist orientation (Hargie et al 1978). Integration of teaching skills and increase in length of lessons and number of pupils as the programme progresses are features. Turney et al (1976) provide an Australian perspective on research, theory and practice, and McIntyre et al (1977) in their review conclude that 'Despite literally hundreds of investigations of its various components, only little that is conclusive or reliable can be said about its value or effectiveness.'

Bierschenk (1972) conducted a careful series of experiments on microteaching with 96 student teachers in Sweden. His conclusions as to the benefits of the method were not too positive or enthusiastic. He could find no significant differences in self-assessment between students who had undergone microteaching and those who had had more traditional tutor comments.

Patently we are not yet certain as to all the outcomes and intricacies of this method. It has been employed in clinical training sessions in medicine, particularly in such delicate areas as learning how to interview psychiatric patients, and several investigators have analysed its use in this way (Suess 1970, 1973; Turner et al 1972). All tend to agree that it has a part to play, within limits, but that the setting up of properly structured learning situations needs much care and thought:

> 'The use of self-observation of TV recorded interviews allows more accurate, objective evaluation of the student's strengths and weaknesses as a therapist, and this is experienced more clearly and vividly from videotape than from written verbatim and process notes or the recollection of what happened in the "live" interview. There is no doubt that the more conventional methods of supervision and evaluation also would have produced similar results, as they have been doing for years. However, we believe that the use of video-tape causes the process to occur more quickly, more objectively, and more forcefully.' (Suess 1970.)

Teather (1973) brings out this point when describing a complex use of CCTV and role-playing under microteaching conditions to teach adult students about

committee work. TV recordings 15-25 minutes long were played back immediately and analysed. Such sessions made a great impact on the students and, though scheduled for two hours, sometimes lasted three or more.

Just what actually goes on in this process of self-confrontation has been made more explicit by several writers. Wilmer (1967, 1968) sums up ideas about why seeing oneself on TV is different from being told about one's performance by somebody else. It is more objective and therefore more trustworthy, more liable to prepare the ground for change.

Walter (1975) has established a generally useful paradigm for the employment of TV in any kind of teaching process involving the question of self-awareness. He used 133 business studies students at Berkeley and 144 at the University of British Columbia, in groups of four to seven individuals for a series of trials and experiments. Basing his analysis on the theory of Kurt Lewin (1947) that 'Lasting behavioural and attitudinal change occurs via a three stage process: unfreezing, changing, and refreezing' he concluded that though self-confrontation via TV is quite good for unfreezing (ie breaking down psychological barriers to change), it does not by itself stimulate change or better behaviour, nor is a verbal accompaniment from a teacher a sufficient additive. Immediately the unfreezing has taken place students must be given clear models on which to base their new behaviour and to 'refreeze' on the desired pattern - another example of the even more basic principle that students learn better when they know where they are going.

Part of the trouble with trying to decide how well a process is working, and part of the reason for frequent findings of 'no significant differences', may be that the evaluators try to force uncongenial categories on to student respondents. Moss (1973) has encouraged students to provide their own scales for judging videotapes, on the model of Kelly grids (Kelly 1955), and concludes that this is a hopeful method of elucidating the precise role that can be played by TV in the learning process. Flood Page (1976) has combined self-confrontation with small group teaching of mature students (all themselves teachers). The students were asked to make free comments on the method, and analysis of their responses disclosed that, while many were initially apprehensive, the general effect could be classed as reasonably beneficial. Having to present and discuss topics actually in a TV studio seemed in general to make the sessions more civilized, better prepared, and better thought out than in an ordinary classroom. There is obviously plenty of scope for further detailed investigation of the man-manchine interactions in this area, as McKnight (1971) also suggests. This shift of attention towards microteaching or some other form of self-observation work has been sufficiently strong for a reminder to be given of the other TV applications in education (Nias 1974), such as recording slices of life, whether in schools or in other locations. The availability of various kinds of portable recording equipment has assisted this development.

Despite this activity and interest on the part of committed individuals and particular institutions, it has to be recorded that the general picture of scale of use has not changed: it remains patchy and low. Some teachers have even been unwilling to use TV in their own work because of discouragement from the media people themselves, as Sayer (1973) emphasizes. On the same point, Bartlett (1970) discusses the use of television in teaching mathematics to undergraduates, based on

'amateur' as opposed to 'professionally' produced programmes. The article suggests that television directors and producers are the main enemy and quotes some typical reactions to the 'amateur' approach. Bartlett puts forward a case to support his position. A view from the other side, from a producer in another institution, suggests that the relationship between academic teaching staff and educational television producers needs careful fostering 'In medical training as in other areas of higher education' and that 'Once again there is confirmation, if it is needed, that the personal relationship between producer and academic colleague is of paramount importance in employing educational technology to improve teaching and learning. Sadly the evidence from this study and many other sources is that this relationship still leaves much to be desired' (Metcalfe, in Jackson and Moss 1975).

In this connection two sets of figures can be quoted. In 1972, Hobkirk (1974) conducted a survey of the use of CCTV in British dental schools. Out of a total of 17 schools, 15 had available TV equipment in one form or another, and one other was planning to acquire some; but usage varied greatly as between schools, and the general level was low. This finding is significant inasmuch as dentistry is a subject which lends itself well to TV, and its teachers are accustomed to handling equipment (Grundy et al 1970). In Australia a questionnaire on TV to universities (Clift et al 1973) achieved a response rate of only 46 per cent, presumably from those more favourably disposed towards the medium or more active in its employment. Analysis of the replies led to the conclusion that TV was little used and that transmission of recorded lectures was declining, though there was more effort to enrich and personalize learning. Most large central facilities were not being used in the ways originally envisaged and there was a lack of proper liaison between teachers and educational technology departments.

The advent of the video-cassette and video-cartridge has, however, provided new possibilities for the use of television in education. Leedham (1973b) estimates the potential of the video-cassette, and points to its 'particular ability, at a comparatively low cost, to record and play back colour', and continues: '... We have in the video-cassette machine a system of recording, storage and playback which is contemporary in terms of communication media, apposite in terms of its relevance to students and logical in that its outlets are a million-fold already subscribed and located.'

Pronay (1979) describes the use of video-cartridges in a course giving an introduction to uses of historical evidence; students studied recordings on a self-access basis in the library as part of a package which included worksheets and a folder of documents. Self-assessment of some assignments was a feature of the course which showed remarkable attendance and show-up of prescribed written work.

Harris and Kirkhope (1978) have studied the use of video-cartridges on a range of topics for self-instruction in the library. They note that although the cost of individual cassettes may not seem very great, if there is a build-up which is not monitored, precious resources can be used up very rapidly. Sales may offset the high cost but a high charge and large sales would be needed.

For technical reasons, other devices, such as EVR, using photographic film, seem to have made relatively little progress against the cassettes, using

magnetic tape. It is the use of magnetic tape which allows the local recording facility which alternative systems lack. Thus the development of such things as video-disc systems is placed at a disadvantage as far as education is concerned.

Moreover, the situation is not helped by the lack of standardized equipment. This lack has long been a stumbling block, and the obstacles to more extensive use and interchange have become more widespread now that several different methods of cassette TV recording are competing for the market. Such a confused situation discourages people from acquiring equipment because of uncertainties about whether a particular machine will continue to be available and how large a selection of tapes will be obtainable. Manufacturers are also coy about disclosing figures of how many colleges possess their wares (Whittington 1973), and altogether the position does not favour growth and good educational development. It is a fairly clear-cut case of educational values cutting across commercial values, probably to the benefit of neither. Imagine records which could only be played on their own special players - how this would alter the pop charts! And lurking in the back of this thought is the further one of whether the idea of every college having its own TV production rig was not itself a step down a wrong road? For instance, the establishment of CCTV consortia with a mobile recording unit serving a number of colleges of education, themselves equipped with modest CCTV facilities, reflected changed DES thinking about the need for installations based on a 'mini-BBC' approach which the first generation of CCTV-equipped colleges had followed (Northern Group of Colleges of Education 1965; Southern Group of Colleges of Education 1965).

SUMMARY

1 Television, both open and closed circuit, has been studied to a much greater extent that have films.

2 Both can be used to teach equally as well as traditional methods, but differences between the effects of the two media are difficult to demonstrate. (This may be because research has not asked the right questions or has not studied long-term effects enough.)

3 As with still pictures, educational targets can be better reached if moving pictures have an adequate verbal accompaniment and are integrated into a coherent system rather than used in isolation.

4 The preparation of such a system usually demands more work from teachers than traditional methods have had devoted to them.

5 Just what are the most significant elements in instructional moving pictures is not clear; but high technical finish does not appear to be important, nor does colour.

6 The best length for a moving picture session may be as little as five minutes. The upper limit would appear to be about 30 minutes.

7 Decisions as to whether TV, 8 mm or 16 mm films should be used tend to be based more on technical and administrative considerations than on instructional grounds.

8 Student reaction to films has been favourable or neutral, and to TV has been mixed.

9 TV is accepted by students if it enables them to see things which have been difficult to observe or envisage before; but it is not popular as a direct substitute for lectures, unless it makes available lecturers of high calibre.

10 It can be used to show students (eg trainee teachers) their own behaviour; but this process may have a harmful effect on a minority.

11 Short moving pictures can be used successfully to trigger off discussion.

12 Students may find filmed demonstrations helpful, but like to have the human demonstrator there as well.

13 It may be suggested that further research could well pursue the study of the significant elements in the make-up, timing, and length of moving pictures; and might also try to elucidate the interactions between different types of individual and the media so as to make explicit which students on which courses will get the most benefit from them.

Inquiries into the use of sound without pictorial accompaniment have not been plentiful. In certain departments of higher education such as music, medicine, or some biological studies, significant sounds or sequences of sound form part of the normal content of the subject matter, and modern facilities for the faithful recording and reproduction of such sounds enable students to hear more clearly and more often things they need to know. The significance of this hardly needs demonstrating; but it must be emphasized that the technical availability of such sounds does not, by itself, guarantee better learning. There must be a proper system, providing adequate time, space and equipment to bring the sounds and the students together as often as necessary. Recorded sounds as a more general teaching method have their major place in language teaching, whether foreign or native, and language laboratories in particular have been developed and installed in an increasing number of institutions. As in the case of overhead projectors these aids have come into use on a fairly wide scale without the accompaniment of much educational research, though the situation is now changing; and a number of universities and institutions of higher education in Great Britain are looking at language labs scientifically.

While laboratories have continued to proliferate, it is still not always clear that the investment justifies the results in terms of learning. The basic cause for this uncertainty lies in our ignorance of how language is learnt. Much hope is expressed with regard to language labs, but an attitude of cautious exploration is probably the most sensible at present. Both Dakin (1973) and Lindsay (1973) put this point of view in eloquent terms. Dakin offers practical guidance about the kind of thing that can be done in the early stages of language learning and lists the nature of learning under lab conditions:

'1 Each learner can work all the time.
2 Each learner can work at his own pace.
3 Each learner can work on his own materials.
4 Each learner is responsible for his own performance.
5 Each learner receives individual attention from the teacher.'

He concludes that it is easier to list these possibilities than to exploit them in a coherent programme, and that (we have been here before) the chief benefit of new techniques is that they force the teacher to define his aims. Lindsay (1973), pondering on ten years of use, concludes that so far labs have shown themselves to be useful for drill and repetition, but not really productive in other ways. There has been a tendency to use them too intensively, to try and make them into brainwashing machines in isolated cubicles, without regard to what other effects they may have on students - effects which may be counter-productive to good learning. Widmann (1970), in the report of a survey at Tübingen, indicates what some of these effects may be. After four terms' lab course designed to improve fluency and spontaneity in speech, most students reported the experience as valuable; but

many disliked interruption and correction by the teacher and felt inhibited by the fact that their mistakes were overheard. Some, indeed, were quite appalled at the revelation of their own inadequacy, and many noted headaches, weariness, and disturbance from neighbours and equipment. Some of these deleterious effects were in part overcome by allowing students to take a turn at the console, where they not only found that the teacher's job could be hard work but also that their own mistakes were not unique.

Certainly the maturity of the students and their willingness or reluctance to face their own errors and shortcomings would appear to be something that needs taking into account. Whittaker (1974), reporting on experience at the South Warwickshire College of Further Education with 75 mature students, found that generally they enjoyed using the lab and benefited from it.

A careful experiment by Freedman (1969) showed that students at Reading University who were taught about the use of the French infinitive as a noun learned better from a language laboratory than from a lecture, but she nevertheless concluded soberly: 'The Language Laboratory is a useful tool when properly used. One of its most important applications may lie in the effect it has on the student's attitude to foreign language learning. He may thus achieve better results because his interest is held and he is highly motivated to learn. This may well turn out to be the major contribution of the Language Laboratory to foreign language teaching.' As with so many other aids, technical and descriptive papers (eg Crocker 1965; Weston 1968; DES 1968) and enthusiastic accounts of what the laboratory ought to do, are much more common than evaluative research, though this is now growing. Henderson (1975) describes the design and use of the language laboratory for the teaching of interpreting and indicates the facilities required for this specialized application. The role of the laboratory in a multi-media system, with a much greater degree of flexibility than the traditional laboratory can provide, has been investigated at the Free University of Berlin (Mackievitz 1974). The Centre for Information on Language Teaching in London endeavours to keep an up-to-date record of what is going on in the field.

A much publicized inquiry by Keating (1963) in the United States was unable to find any benefit to children from the presence of language laboratories in their schools, but on general grounds one would expect them to be of more use with older students in areas of less stress than the New York High Schools which he examined. Forrester (1968) has pointed out the deficiencies of Keating's survey, and gathered together material on research into language laboratories, mostly in schools. She makes clear the numerous possible variations in both laboratory equipment and method of use that need to be taken into account when the effectiveness of such installations is to be appraised. She also suggests that an important factor may be the ease with which equipment can be made available. An ordinary tape recorder in each of 30 classrooms may be better than an elaborately constructed, technically sophisticated 30-position laboratory. As with other aids the reactions of students and teachers to the equipment require study. Such reactions are bound to be an important controlling factor in development, and are an important field for research. In this connection a brief inquiry by Stock (1966) in the German Department of the University of Adelaide demonstrated that while first-year students were well aware of the laboratory's imperfections almost all wanted to go on using it later in the course.

Descriptions of the use of the language laboratory in a number of courses, for example in a Russian department (Devereux and Grayson 1978), show how the laboratory may 'cease to be a mere passive adjunct, but become actively relevant, and be recognised as being relevant.'

At the University of Southampton, Whittaker (1976) has used the laboratory in the teaching of classics in a variety of learning activities; for some of these he adopts a programmed learning approach. Work in the laboratory has never exceeded 15 per cent of course time so use is concentrated. Material is carefully prepared: six hours of writing and one hour of recording time are needed for a 25-minute tape; the value of the facility for simultaneous work with individuals is emphasized, and it is noted that passive familiarity with concepts can be translated into active manipulation of them with consequent deepening of understanding.

Though radio lessons have been in use in schools for many years little attention has been paid to them in higher education. Today the tape recorder can be used with or without a radio set to provide a similar instructional experience. Snyder et al (1968) report that students learned as much from broadcast tapes as from conventional lectures in an introductory psychology course, but did not like the disembodied voice. Similarly when preclinical dental students were asked to state a preference for alternative ways of presenting the material delivered in a course of oral physiology lectures they ranked recorded tapes bottom, below television, and well below films and duplicated handouts (Flood Page 1967). (It must be emphasized, however, that this was a purely hypothetical choice: the students had little or no experience of these other methods that they were offered.) The completely disembodied voice may therefore be effective as a teaching method over a short period, but there are doubts as to whether it would be acceptable as a major feature of the higher education process, without a proper admixture of human interactions.

The use of sound-tapes has in fact become much more general in the last few years, particularly since they have become available in the handy cassette form. Engel and his associates (eg Engel and Wakeford 1971; Engel et al 1974) have carried out an extensive series of researches into the use of audio-tapes for teaching basic sciences to medical students. They have found that students can learn well from the tapes, but that matters are improved when the student is provided with some sort of handout on which he may make notes and which he can take away with him. Care also needs to be taken with the style of speech delivery on the tape - a conversational tone and frequent use of nouns rather than pronouns is required. Straightforward reading of a written text is inadequate; and, as always, it is no good producing tapes without proper consideration of the logistics of their availability to students. Overall, though, they can provide variety in any subject much concerned with factual learning, and a substantial minority of students find they can learn better from tapes than from books.

Individuals have tried out several different methods of employing their potential in other areas. At the University of Texas audio aids have been used in laboratory teaching since 1964. Although results are difficult to measure, Lagowski (1966) notes that time is saved for both students and instructors, students work at their own pace and show better technique, and the tapes are useful for absent students or for remedial purposes. Moffat (1970) reports on a system at Standford

University whereby a teacher tape-records his comments on engineering students' project reports. The students can play the tapes back privately, making their own notes in the reports as they go. Students prefer this to a written comment, find it easier to take than a direct confrontation with the teacher, and yet feel at the same time that the teacher has given them a valuable slice of his precious time - up to 45 minutes. Gore and Rayner (1972), at the Australian National University, describe a system in which tape-cassettes are used to teach students how to handle apparatus, and include sound recordings of machines going wrong. The controls are arranged so that students can manipulate the apparatus and listen to instructions at the same time, in a way that would hardly be possible with either printed or visual aids. These three examples suggest the variety of use that is possible.

Two articles by Ackers and Oosthock (1972, 1973) report the evaluation of an audio-tape mediated course in a faculty of law. They conclude that the overall effect is more positive than that of lectures and the system supports the anxious student. Capable students with conceptually oriented minds gain only when their motivation is low; the reverse appears to be true of students with lower ability and factually oriented minds.

Popham (1961, 1962) found that taped lectures presented to a whole group can be as effective as a traditional lecture. Menne et al (1969) confirmed and extended Popham's work by investigating individual presentation in lieu of regular class attendance. Student reaction to the method was generally favourable. It is suggested that low-level courses which are largely content-oriented could be most appropriately presented in this way. The ways in which external students use audio-tapes has been examined by McDonald and Knights (1979). Their three main uses are in motivating study, in maintaining morale, and as sources of information for those students who prefer to obtain it by listening, but useful nevertheless for those who prefer print (almost half the students sampled).

The availability of variable rate speech (VRCS) compressors has made it possible to save 32 per cent of time spent in learning cognitive information by self-instructional methods; there was also an increase in average grade over the normal speed tape-recorder group (Short 1977). The crucial factor in the use of speech compressors for lecture review, according to Rippey (1975), seems to be the facility for student control: students can speed up and slow down.

It appears probable that psychological and sociological factors may be important in this area, as they have been found to be when computers are introduced into human institutions (Mumford and Ward 1968). It may be surmised that, when motivation is high, methods will be tolerated that might in other circumstances be unacceptable. In this connection it is most interesting to study the experience of the Open University, to see how its students react to the particular mix of human and mechanical teaching which they are offered.

SUMMARY

1 Little research has been done in this area, though work is now on the increase, particularly with regard to language laboratories.

2 It appears that although recorded sound on its own was not usually liked by students in the past, increased familiarity with the medium seems to have resulted in more favourable attitudes.

3 It is suggested that language laboratories may help to increase student motivation; but it is important to note the diversity of situations encompassed by the term 'language laboratories'.

4 Like other technical aids tape recorders enable students to use their time to better advantage in repeating material in the absence of a teacher.

5 The field for further research is wide open, especially in view of the diversity noted in 3 above.

4 PROGRAMMED LEARNING AND TEACHING MACHINES

The principles of programmed learning have been canvassed on an extensive scale over recent years, and much research on the subject has taken place. The viability of programmed-learning sequences for students in higher education still remains in doubt, as most of the work has been done with school children, apprentices, or members of the armed forces (Wallis, Duncan, and Knight 1966). The principles underlying the construction of programmes have frequently been formulated, as in Leith's A Handbook of Programmed Learning (1964). The material to be learned must be meticulously analysed into small, completely comprehensible units which must be presented to students in a carefully ordered sequence. The effect of the programme on the students for whom it is intended must be carefully studied, and the knowledge derived from this study used to improve the programme. The material is presented when the student is ready for it, not at an arbitrary pre-determined time or age. Correction of students' work must be immediate, and successful learning must be guaranteed to those who complete the programme, which they can usually work through at their own pace.

Once these principles are accepted, the analysis of the material worked out, and its new structure decided upon, the programme may be presented in several ways. It can be a straightforward book, akin to a traditional textbook, though in shorter sections and in an order geared to the reader rather than the writer; or it can be a 'scrambled' book in which the sections do not follow each other on consecutive pages, but are haphazardly located in order to make the reader physically as well as mentally active, and to prevent a mindless turning over of the pages. Alternatively the programme can be put on to a pictorial tape and used in a teaching machine. Today it is becoming more common for the programmes to be built in to computer learning systems, and with this technology programmes can become much more elaborate and sophisticated than much of what has in the past been thought of as programmed learning. In addition, many tape-slide sequences and similar aids employ varieties of programmed learning. Whatever the medium, the basic principles remain the same - the material is highly organized to be of benefit to the learner, and if things do not work out as planned the first consideration is to alter the material, not to blame the learner.

As was indicated earlier, experiments in programmed learning in Great Britain have mostly been performed outside higher education, but a number have tested the usefulness of this technique with students at the higher level and enable us to give a sketch of its applicability at this stage. The evidence seems to point to the conclusion that minute attention to pedantic details of programming methods are unimportant, except where computers are concerned, and that reasonably homogeneous groups of students learn no better from programmes than from traditional methods. On the other hand, when a teacher is confronted with a mixed bag of students or is trying to teach a subject which has usually had a poor reception from the class, programming may show considerable advantages. For instance, Castle and Davidson (1969) at the Medical School of the University College of Rhodesia,

used programmes to teach bio-statistics and genetics to medical students who came from diverse backgrounds with varied qualifications, and who had found these subjects difficult. They were each given a programmed text which they could read as often as they wished; but their overall rate of progress was controlled by regular tests on specific parts of the material. The programmes produced better learning in the students, and no significant differences in performance were revealed on account of race, sex or other background factors. The students preferred the programmes to lectures.

There is a danger that too careful adherence to classical programming technique may produce a text which induces boredom in the students, and thus becomes self-defeating. Student ennui is a factor that must always be taken into account at this level. Thus Leith (1967) has shown that the better a student knows a subject and the more his mind is filled with appropriate, clear, preparatory concepts, the less need there is for him to make overt (spoken or written) responses to the questions in a programme, in the way normally required of school children. Covert (mental) responses are quite sufficient to ensure adequate learning. Poppleton and Austwick (1964) came to the same conclusion when comparing grammar school pupils and postgraduate students. The school children learned significantly better from a programme requiring overt responses, while this condition made no difference to the postgraduates. There are still problems here, however, as to whether the different types of response produce different depths of learning.

Wright (1967) demonstrated that with undergraduates who were given a programme on the subject of operant conditioning, a straight-through text with a few questions at the end on relevant major points was a better teaching instrument than one with numerous questions throughout the text, of the kind normally used with school-children. Biran and Pickering (1968) tried out different arrangements of the same programmed book when teaching mature student nurses a course in genetics. Results indicated that environmental variables, such as available time and the degree of stress which students felt, had significant influences on who learnt how much from which kind of book. When these extraneous factors were allowed for the students learnt more quickly from a straightforward version than from a scrambled one. The authors of the experiment therefore concluded that programmes for mature students need not be as complex in structure as those for children. Roderick and Anderson (1968) found that while senior school children did well with a programme on psychology designed for undergraduates, the undergraduates themselves learnt no better than from reading a summary of the material contained in the programme, and took four times as long to complete the programme as to read the summary.

Hartley (1968) studied the effect of a programmed text compared with an ordinary textbook in teaching descriptive statistics. He found that when no compulsion to learn was applied, other than specifying the date of a test, the programme exercised more control over students' study habits and gave better average marks in the test. However, those using a programme were less likely to make a thorough job of reading it than the other group made of reading the ordinary textbook. He showed that there was a good case for allocating different types of book to different students on the basis of such personality scales as those of extraversion and neuroticism.

Pikas (1969) discovered that interactions between student learning, type of instruction, and type of test were not simple. He used 268 university students in three groups, two having different types of traditional teaching and one being taught by a programme. The last group did better on a test given immediately after the instruction, where verbal reproduction only was required; but the group which had had traditional teaching involving activity on the students' part did best on practical tests, especially if these were delayed. Another comparison between programmed learning and lectures was made among 77 medical students on the subject of electrocardiography (Owen et al 1965). Tests of what had been learnt showed no significant overall differences between the lecture group and the programmed group. Further analysis showed that the less able students and overseas students did better with the programme, and while men generally preferred to learn from the programme, women preferred lectures. (Such a finding might be of considerable practical importance in course arrangements, and therefore the experiment would be worth replicating with other groups to study how generally applicable its conclusions were.) Forty-five first-year undergraduates in aero/auto engineering at Loughborough College were given a course either by programme or by lectures and tutorials. An immediate achievement test showed no apparent differences between the groups, but a later retention test showed significantly greater variability among the programme group. Further analysis demonstrated that this was because those high in mathematical ability (as judged by other means) had done well with the programme, while those of low mathematical ability had done badly (Unwin 1966b). Both Hogg (1967) and Hoare and Inglis (1965) have reported comparisons between programmed learning and small group tutorials on certain chemistry topics. In both cases the student reactions were mixed, but generally favourable, while the teachers considered the programmed method a good one. Connor (1968) found that some engineering students given a programmed course in dynamic equilibrium did significantly better than those taught by traditional methods. On the other hand, on three tests administered at different times, Orr (1968) found no significant differences between the amounts two groups of sailors learnt about atomic structure, one group having had conventional lectures and the other a programme. As in so many of the studies we have reported one would like to know more about the psychological and sociological variables involved.

Several experimenters have examined the effect of giving programmes to students under different learning conditions, in different formats, or with different time allocations, etc. Stones (1966a) taught some basic facts on psychology to three matched groups of student teachers - 120 in all. One group was given a series of 45-minute lectures, one a programme on a teaching machine, and one the same programme in a printed loose-leaf form. The students liked the programme and learnt equally well from the machine and loose-leaf versions. The same worker also tried varying other conditions with regard to the loose-leaf version (1966b). Five randomly assigned groups used the programme under varied conditions as to time allotted for study, amount of supervision, and whether they worked independently or in groups. The differing conditions had no significant effect on the amount learnt or on the students' attitudes towards the process; and Stones concluded that a well validated programme teaches as well as a good lecture, and is more convenient and flexible in use. In the experiment by Connor (1968) already referred to, one group was given the programme by machine and one in a printed version. No significant differences in learning resulted from the different treatments. Unwin and Spencer (1967) administered a revision programme on

alternating current theory to 26 technological undergraduates, half of whom were supervised during the process and half of whom were not. Once again both groups learned equally well. The programme on electrocardiography already referred to was also presented to students in two forms: scrambled book and machine (Stretton et al 1967). There were no significant differences in learning between the two different groups.

Hogg (1973) studied student attitudes to programmed learning by means of a questionnaire (567 respondents) answered by 16 chemistry departments in institutions of higher education in the British Isles. The response was generally favourable. Students of all types and abilities found it useful, though not particularly interesting, and would welcome more, particularly for private study and revision. Hartley (1974) reviewed 20 years of programmed instruction, and came to some reasonably firm conclusions. He emphasizes that 'The concept of programmed instruction has so widened since its early beginnings that, today, as a single entity, it almost defies definition'. Research has spread into new areas as the issues have been seen to get more complex, and the line between research on programmed instruction and PI per se has become blurred. Though the overall concept is a valid one, bits of the process can be missed out and it will still function well. It is not always clear in which situations it works and in which it doesn't. What is vitally necessary is that objectives should be clearly specified, learning tasks carefully analysed, teaching strategies precisely applied thereto, and the whole process subjected to constant monitoring and feedback.

Teather, Hardwick and Collins (1973) translated parts of the contents of two introductory-level biology lecture courses into programmed form, and subsequently compared the performance of students using the programmes and students attending the lecture course. Though the evidence weighs slightly in favour of the long-frame, predominantly linear programme, the investigations throw some interesting light on students' reasons for choosing a particular method, and on the effect on the participating tutors. For example, the assessment of students' pre-course knowledge 'came to be regarded as a valuable exercise in its own right, as did the close scrutiny of students' errors in learning, which the revision of the programmes necessitated.' The planning and presentation of the programme content was seen 'to have relevance for the production of other teaching notes, and the responses to the questionnaire gave insight into students' expectations of teaching.' The authors conclude that there should be a plurality of teaching methods available to students, and that different sections of a course could be taught by different methods.

Leytham (1972) reports on a programmed second-year course on the psychology of learning. He found that students were mainly favourable towards the course - and all passed. His conclusion is that 'The course, as conducted, probably represents a stage roughly half-way between short published programmes, where the writer is absent and frames are fixed in advance, and a systems approach to a whole degree structure, where staff and students interact throughout the procedure. At the university level at least, our experience would suggest that the latter is the ideal to work towards.'

Croxton and Martin (1970), writing on the development of a system of programmed learning in a civil engineering department, in which a library of programmes is

used in conjunction with student-marked tests and tutorials, conclude that seven years' use of learning programmes has shown that the majority of undergraduates at all levels react well to the system, and that the best results are obtained from a system which gives 'opportunities for frequent informal contact between students and between students and staff. Students have not been found to work well in isolation.' They also point to the need for 'Uniform scheduling of the work load with the incentive of regular testing. Some students, particularly those lacking in incentive and drive, seem to need pacing in this way.' Their article again emphasizes the demands on time required to prepare, and subsequently to evaluate and revise, programmes, They give as an example the total of approximately 1000 man-hours needed to convert, and revise, 60 programmes from Imperial units to Standard International units.

Many of the results that have been quoted suggest that there is often no particular advantage to be gained from preparing material in programmed form commensurate with the effort that goes into the preparation, if one studies the average amount learned. A most horrendous warning in this connection comes from the USA (Manning, Abrahamson and Dennis 1968) where a programme that took about 3000 academic man-hours and 1000 hours of secretarial time to prepare was shown to be no better as a teaching instrument than traditional methods. Students probably learn better from good programmes than from bad textbooks and lectures; but better from good lectures and textbooks than from bad programmes. Because of the systematic care with which they are prepared the hope is that programmes will consistently maintain a higher standard than traditional methods and will also enable more account to be taken of individual differences in learning. It is doubtful if we have yet reached that desirable state.

An interesting paper by Unwin (1966a) proposes that there is to some extent a spurious air of precision about much programmed learning. He considers that programmes cannot be analysed or synthesized in any really scientific fashion, and that their construction is best viewed as just another aspect of the traditional art of writing, A good programme, he suggests, works on the reader as a good novel does. He also calls attention to the fact that the normal process of programme validation tends to produce a result suitable for the dullest member of the class. He suggests that one of the key matters to which not enough attention is commonly paid is student utilization of time. Under conventional instruction, Unwin points out, the student may be doing no useful work for long periods, while with programmed instruction the proportion of time so wasted can be much less. Certainly time may be saved in one way or another, after a heavy initial expenditure in that commodity, as has been reported by Stavert (1967, 1969) in connection with programmed instruction at the Royal Naval Electrical School. Here the introduction of programmes for the first 12 weeks of basic training in electricity, electronics, and radio for 16-year-olds enabled 7 out of 15 instructors to be freed for more advanced work. At the same time it was found that full automation with teaching machines and complete withdrawal of the human teacher was detrimental to good learning. A mixed system has therefore been evolved to make the best use of both human and mechanical elements. One situation in which a programmed approach proved beneficial was in a difficult technical area of underwater sound recognition. It was concluded that programmed instruction properly managed and applied to specific problems can make a positive contribution to the improvement of technical training.

It would seem, therefore, that one place for programmes in higher education might be as useful instruments for revision of basic, elementary material, which it is usually assumed (not always with justification) has been thoroughly learnt at school. Material of this kind does not change rapidly, and teachers get bored going over it time after time. Another situation in which the use of programmes should be considered is in connection with any subject in which students seem to find consistent difficulties in learning, or in which teachers are in short supply, such as statistics. Once good programmes are prepared they can be made available to an extent which teachers can never be; and the analysis of the situation necessary for programme-making may have beneficial repercussions beyond the immediate end-product itself. The usual lengthy initial effort in preparing programmes may then be seen to be justified in the saving of time and energy over a period of years. Just what a 'programme' might consist of in these circumstances is not altogether clear. An article by Tobin (1969) shows how general the meaning of this term has now become. For most cases, at the level we are considering, a straightforward statement of facts and concepts would probably be sufficient, provided it was properly tested for applicability to the student population for whom it was intended. The preparation of a programme of this type need not be inordinately time-consuming. In fact it could easily be no more than a series of well prepared lecture handouts: a simple device, very popular with students (Saunders et al 1969; Thomson 1966) but resisted by many teachers with an inappropriate overload of emotion.

Worth noting and thinking about is an interesting piece of work by Leith and Britton (1973). A 10-hour course on the principles of programmed learning (PL) was given to 100 education students before they went on teaching practice, and their grading on the practice was compared with that of a control group (N=108) who had not had the PL course. About half the students in the PL group got high grades compared with less than a third of the controls. This result was statistically significant at the .03 level: a suggestive finding.

SUMMARY

1 The development of these techniques has been accompanied by a healthy amount of research.

2 Programmes can often be successful in teaching subjects in which (a) human teachers are scarce, (b) students have generally found great difficulty, and (c) students start off at varying levels of knowledge and competence.

3 In higher education programmes do not need to be elaborately constructed, nor is machine presentation better than book presentation, though computers may offer some advantages.

4 Programmes are useful for less able students and for those for whom English is not the first language.

5 Careful matching of student psychological types to programme types produces beneficial results.

Programmes can save teacher time (after a heavy initial investment in this commodity), but students prefer to have both teachers and programmes.

7 Women are probably not so fond of programmes as men are.

8 Further research might well look further into the more exact matching of different types of programmes with different types of students (Heidt 1978).

While most of the items we have dealt with so far have been used and studied in isolation, an increasing body of thought is coming to prefer the idea of using different kinds of apparatus in various mixtures to give the best results. The good teacher has always tried to adopt an approach that varied with the individual and the circumstances, but experimentation with such a multifarious technique using technical aids has not been frequent because of the high initial expense of setting up such a system. However, as technical aids have become a more familiar part of the educational scene, and as the general level of expertise and knowledge of these matters has risen, the difficulties of implementing such procedures have been felt to be less, and several efforts have been made to use more complex systems. In this section we shall give accounts of such work and explore some of the implications of these operations.

TAPES AND SLIDES

The normal use of slides has been touched on in an earlier section. Here we are concerned with the use of slides plus recorded audio-tapes to provide instructional material which can be used independently of the teacher. Such material can be called programmes in the sense outlined at the end of the previous section. If students can learn equally well from them as from lectures, seminars, and other teacher-based methods then there is some prospect that the regular and extensive use of such means may help to cope with increasing numbers of students without loss of learning quality. Holloway (1964) tested out a set of slides and a tape on cavity preparation for dental students, and compared it with the ordinary course of lecture demonstrations as regards the amount the students learnt. He found they learned as well from the slides and tape as from the lectures, and in one respect the tape group surpassed the others - in a verbal test immediately after the tuition was complete. The non-human version had the advantage that it was more concise than the usual teaching, and could be replayed on demand.

Harden and others at Glasgow spent some time investigating the use of tape-slide machines in medical education. The report of one experiment of theirs (Harden et al 1969) recounts how a small group of 12 fourth-year students were taught part of an endocrinology course by a carefully arranged tape-slide series, using either an audio-visual tutor-machine or simpler apparatus. The students taught in this way significantly improved their positions in class and reacted favourably to the experiment. They took, on average, 50 per cent more time to go over the same material as the lectures, and preferred the more elaborate equipment. Three foreign students in the group did particularly well. In another experiment, using an auto-synchronized tape-slide system (Harden et al 1968), it was found that in medical teaching 45 minutes is the maximum acceptable duration for most students when using this technique.

Fletcher and Watson (1968) describe another use for such apparatus: to enable students to learn microscope technique without the necessity for a teacher standing over them, or a book awkwardly open beside them. Flood Page and Squier (1970) report the effectiveness of a tape and slide system to teach dental students anatomy at Aarhus in Denmark. At Rotterdam De Vries and Huber (1969) have used a battery of 20 tape-slide machines to teach pathology to medical students. They confess themselves unable to offer convincing evidence that this method produces better learning; but it has proved acceptable to the great majority of students and has enabled the staff to reorganize their own timetables in a more congenial fashion. The system is integrated with small group discussions, and the actual use of the machines is supervised by senior students. In the medial school of the University of Newcastle-upon-Tyne a tape-slide system has been developed since 1967 making extensive use of student feedback as to the value of the material offered. Though Amos et al (1969) do not report any data relating to increased learning by this method, they do give evidence of considerable student liking for the system.

At Birmingham University Medical School (Curran and Jones 1977) the general pathology course in the first clinical year has been largely reorganized around 19 tape-slide programmes linked with tutorials and practicals, and 6 quiz-seminars. Projected slides even play a prominent part in the end of course examination. Both staff and students like the course, and examination results have improved considerably since the new system was inaugurated. As a slight variation on this theme audio-tapes have been used with self-instructional booklets to teach preclinical students physiology at the Charing Cross Hospital Medical School in London. Acceptability and effectiveness were similar to that with the pathology students at Birmingham (Davies, Gale and Clarke 1977).

Not all experiences with this sort of course have been so well received or produced such good results. For instance Elton et al (1971) found that in comparing the use of tape-slide presentations and lectures as teaching and learning systems in a university physics course, there were no measurable test result differences but that the students preferred a 'live' lecture. They conclude that tape-slide presentation is at its best as an adjunct to lectures, particularly when linked with self-teaching books.

Efforts have been made to develop ways of using the technique other than by means of individual student access. Marchant (1974) describes large group instruction using tape-slide presentation and concludes that this is a viable alternative to individual use. The conclusions reached by Holroyd et al (1970) at Glasgow, working with a sample of fourth-year medical students, are that a group-paced presentation of tape-slide programmes was probably just as effective as self-paced presentation, that it was administratively more convenient and gave some saving in cost, but these students did not like the method. The authors comment that they were surprised how much they learned of the qualities and deficiencies of the programmes by being in charge of group presentations. They suggest that the group presentation method is likely to be most successful in the initial or transitional stages of replacing conventional lectures; but they conclude that they are 'not very hopeful for its future as a routine method of instruction for students of this age and sophistication'.

The method is extensively used by medical men who borrow tape-slide sets from the Medical Recording Service organized by the Royal College of General Practitioners, operating from Writtle near Chelmsford. No research information on the efficacy of this service is available; but the fact that world-wide use of it is made by scores of thousands of doctors speaks volumes for its acceptability as a method (Graves 1968b). It should not be a difficult step from using only tape and slides to the development of more varied sets of equipment which transport well-adapted learning quickly and easily to widely scattered students. One hesitates to use the current jargon word 'package', but it does seem most applicable in this context. And packages of one sort or another have loomed increasingly large in many discussions and suggestions about the use of technical aids in education. From the selected cases reported here it is apparent that, as with most of the apparatus we discuss, packages themselves, while potentially efficient, depend for their effectiveness on the careful design and implementation of a good learning system into which they are built. The question of whether students and teachers like them can also not be avoided when their use is being considered, and it is more than probable that the actual subject matter itself is another factor that needs consideration. For instance, medical students seem to have different tastes in these matters from physical science students (Garland, Dutton and MacQueen 1977).

MULTI-MEDIA SYSTEMS

It is easy to go from the concept of tapes and slides to the idea of more complex installations where other audio-visual aids, books, specimens, etc, are all carefully put together to ensure an environment of high learning potential. In such an environment each piece of apparatus can do what it is best able to do, and the human beings connected with the system can be reserved for the more subtle functions that machines cannot match. This sounds like an ideal recipe for a large part of education; but when fully implemented it needs considerable expenditure of cash and of technical expertise to function properly. It is therefore only rich countries that are likely to be able to try out such methods until the necessary equipment drops in price and increases in reliability. The most notable examples of such systems, either in being or planned, are to be found in the United States. One has been investigated in the physics department at Harvard by Smith, Schagrin and Poorman (1967) who reached some interesting conclusions. They discovered that previous workers had decided that it was possible to specify behavioural objectives for a given course with such precision that they could be matched up accurately with selected media to attain desired amounts and kinds of learning. Smith and his co-workers had their doubts about this optimistic conclusion, particularly when it came to the operational specification of objectives, but nevertheless they thought it worth pursuing the idea of such a system. Their own studies suggested that learning was more effective and better adapted to the individual in a multi-media system, even though it was not possible to analyse accurately students' different learning strategies. They also judged that present audio-visual aids were quite adequate in number and kind for the postulated task, though refinements and modifications in detail were indicated.

One of the most highly developed of such multi-media systems is in the botany department of Purdue University (Postlethwait, Novak and Murray 1972; Postlethwait 1972). This began in 1961 with a simple use of taped lectures for the weaker

students; but now has independent study carrels for students using tape, slides, specimens, introductory manuals, experiment kits, short films, and any other apparatus or material that may be necessary. The laboratory where the carrels are situated is open for a long time each day, and an instructor is always present to help students in difficulties, to answer questions on the spot, or to give brief oral and practical tests on demand. Regular small and large group sessions are integrated with the multi-media laboratory sessions into a well thought-out learning programme, which produces good results from the students.

Other systems have been developed at Purdue, in veterinary science and engineering (Lindenlaub 1970; Welser et al 1970), and they have been imitated with varying emphasis in many other places. Laboratories and carrels of several kinds have come into operation, of which the dominant feature is the set of prepared materials and AV apparatus available for individual student use, usually on unscheduled time, but often with deadlines for student attainment tests. (Some slight evidence is offered in Jones (1976) that it may be better to have all test items at the end of a session, rather that at intervals throughout.) Teachers are on hand in the rooms provided to answer questions and give advice. In general such systems have proved efficient and popular with students, not always so well liked by staff. Examples can be found in Australia in the schools of biological sciences at Sydney University (Carré 1969; Brewer 1977), and of physics at the University of New South Wales (Arbib and Handscomb 1972) and Flinders University (Marinos and Lucas 1971). In New Zealand, at Lincoln College, a self-instruction course in animal structure and function has proved to be both effective and well liked (Gabb 1978). In North America one can instance pharmacology at Boston (Volicer and Pelikan 1971), library science at Case Western Reserve (Goheen 1970), and chemistry at McMaster University (Humphreys 1971), while from the Massachusetts Institute of Technology Palgi and Sheridan (1977) report a whole-class system to teach nutrition, using slides, programmed texts, scripted lectures, and electronic feedback. (See 'The Feedback Classroom' below.) In Great Britain physics has been given the treatment at Chelsea College (Brandt et al 1974), and at Dundee biochemistry practicals have been replaced by an audio-tutorial system to the benefit, in particular, of medical and dental students (Garland, Dutton and MacQueen 1977). Kenshole (1969) describes an organization at University College, London, to teach first-year engineering students three-phase alternating current theory. Use is made of 16 mm films, slide-stills from the films, class discussion, duplicated handouts, and a short 8 mm silent film. No data are given as to increased student learning, though it is claimed that this does take place. The author does, however, draw attention to the danger of systems such as this: they may remain rigid and unadaptable after the initial fervour of their creation has spent itself.

In theory this should not be so. At Purdue there is continuous feedback from the students as to the efficiency and clarity of all the items that go into the system so that the amount of dead wood and wasted time is reduced to a minimum (cf Unwin's 1966 paper already quoted). This sort of situation would appear to be the ideal towards which purveyors of audio-visual aids should work. The teachers are still in charge of the operation, but they are in charge in a more meaningful and less psychologically stressful fashion for the students and themselves; and there is little occasion for friction and misunderstanding between learners and teachers. Instead both parties co-operate to see how they can improve the teaching materials;

and this co-operation is carried out in a reasonable and scientific manner with the clear objective of promoting optimal learning in the students. Such a set-up lays no great stress on what many would think of as the traditional teaching skills such as lecturing and running seminars; but this new organization may well prove more congenial to many research-minded university teachers. They can use their research abilities in the preparation and revision of first-class teaching material, and are not forced into inept public performances which put them on the rack, nor are they compelled to break off their research at inconvenient moments to go and talk to students. Dowdeswell (1973) has weighed up and discussed the Inter-University Biology Teaching Project, devoted to the development of modules designed for this sort of use, to be closely integrated with laboratory and tutorial work. The universities of Bath, Birmingham, Glasgow, London and Sussex co-operated in this project. Most of Dowdeswell's article analyses the system and its American analogues, but doesn't say much about its effectiveness, which seems to be more or less taken for granted. The changed role of the teachers and their sometimes awkward relationship to the new ways are well expressed:

> 'One of the most profound outcomes of the introduction of self-instructional courses is their effect on the function of the teacher. As a lecturer to large classes he was relatively secure, remote, and unassailable. But in his new role as adviser his task is no longer to dispense knowledge but to share it. He can no longer regard himself as just a specialist in a particular field, for there will undoubtedly be questions and problems posed by pupils which will be unfamiliar to him.... For those who have sought means of achieving closer liaison between staff and students, the new situation provides a challenge which is easily accepted. Others are more cautious in their acceptance of the changed relationship, while some reject it altogether. There is no doubt that failure to adopt independent learning methods in the later years of college stems partly from a misunderstanding of the implications of these changes by members of the university staffs concerned.'

It is notable that he sees the focus of the operation in the students' learning, not in the provision of the hardware and software, and his last sentence sums up a whole world of difficulty in this area with regard to teachers.

Difficulties do, on the whole, seem to be growing fewer with time as systems become more common and their place better understood. Fisher and Macwhinney (1976) review evaluative research in this area and cite eighty-nine examples. They come to a reasonably encouraging, though not exactly enthusiastic conclusion:

> 'Is the conclusion that audio-tutorial (AT) instruction is superior warranted on the basis of the present evidence? Certainly a healthy scepticism is justified. One can find numerous faults in the research and it is easy to rationalise the findings in terms of investigator biases. However, the burden of proof at this point would appear to lie with the disclaimers of A-T effectiveness. The hypothesis must at least be seriously entertained that the A-T method is superior to the lecture method for producing achievement gains and positive affective responses with many students in many subject areas.' (ie Students learn more and they like it.)

Fisher et al (1977) were more positive and emphatic. They assessed the value of a multi-media system to teach genetics to classes of up to 1600 students in

California. They concluded that the system helped students at all levels of ability, but that this success was due more to the teaching strategy embodied in it than to the precise nature of the technology.

Most of the arrangements referred to so far in this section have involved the organization of various technical aids to assist students in specific courses. Perhaps a more promising line is the development of what are called learning aids laboratories, in which a multiplicity of aids are available from which the student can choose. Such laboratories are usually devoted to one subject but not to any one course more than another and the students make their own decisions as to what they want to use and when. The development of such a laboratory at Queen Elizabeth College in London is well described by Poller and Seeley (1977). Here the subject served is chemistry, and this is certainly a subject in which such developments have been well to the fore.

THE FEEDBACK CLASSROOM

This system is particularly associated in Great Britain with the name of Holling (1969, 1974) and the Chesterfield College of Technology. Its basic principle is the expansion of programmed learning technique to cover the operation of a whole class. After one 'frame' of teaching from the teacher multi-choice questions are projected on to a screen and each student can answer in a way that conceals his answer from the other students but makes it clear to the teacher. The latter is thus enabled to know at each stage of his lesson whether the material he has just put over has been properly learnt. He can then take immediate action to go ahead or repeat the previous section.

In Holling's own classroom there are eighteen student desks. On each desk the student can turn switches to indicate which numbered answer he considers correct to the projected multi-choice question facing him on the screen. His answers and their corresponding lights are arranged so as to be invisible to other students. The switches which he manipulates cause appropriate lights to show up on a panel facing the teacher, who can know at once how many wrong answers and right answers have been given and which student has given which answer. A further piece of apparatus even enables constructed responses to be instantly evaluated by the teacher. The electrical and mechanical sophistication of Holling's own system is of a high order, but though the initial labour of setting up the programme is usually heavy it is claimed that learning improves when it is used (Whitworth 1966).

An extremely simple variation on this theme has been tried out in the RAF (Taplin 1969). The only apparatus - the Cosford Cube - is a small wooden cube with differently coloured faces. Each student has one of these cubes, and responds to a multi-choice question by showing the appropriate cube face to the instructor. The advantage claimed over the traditional device of raising the hand is that the student does not show his answer to any one except the instructor, but this seems a naïve claim except in some rigidly controlled circumstances. The use of this technique and other mechanically more elaborate ones has shown the RAF instructors that such devices demand more thorough preparation of lessons and generate more understanding in the class. It is also made plain to teachers how many times

it may be necessary to go over a point before the majority have assimilated it. Harden (1968) describes a similar device making use of a card with coloured strips of paper, which he calls an 'Audience Response Card'. He emphasizes, as do the writers previously quoted, the benefits to teaching that derive from the use of this sort of system.

While many people appear to see merit in such a system, and enthusiasts from time to time write articles claiming it as an important breakthrough (eg Wheeldon 1978) it does not appear to have attracted much research investigation, and how many feedback classrooms are in use is not easy to find out. One hears reports from time to time of their installation, sometimes constructed by local technicians with varying degrees of electronic sophistication, but their subsequent history does not seem to be recorded.

OTHER DEVELOPMENTS

A number of people have looked at other pieces of apparatus available in modern society and tried to see if these could be of special use in higher education. Some of the ideas that have been tried out may seem to have no immediate practical application, but one can never be sure how such things will develop and it is therefore worth giving examples of experiments in this line. In the United States both ordinary telephone (Parker 1968) and radio-telephone networks (McBride 1966) have been used for teaching of various kinds, enabling participants to have the benefit of contact with high-class facilities without the need to travel long distances.

Saklofske et al (1977) compared the use of telephone seminars with ordinary face-to-face interaction on campus, and concluded that the telephone was just as effective from the point of view of academic achievement, but that students didn't like it. At Queen's University, Ontario, between 1972 and 1975, a study was made of large-scale use of both individual and conference telephone calls available to over 2,600 extramural students on 85 courses (Orton 1978). About half the tutors and a third of the students made use of the facility, and liked it, but what effect it had on learning is not made clear. Becker (1978) reviewed research on the use of the telephone to teach classes at a distance. He found about a dozen institutions, mostly in the USA, where such classes had been or were being conducted, and located 200 reports of such activities, but only 15 of these could reasonably be labelled as research, and even among this small number several dealt only with trivial questions. The familiar conclusion was that the instrument was useful, provided it was properly integrated into a well thought-out system.

In this country groups at Cambridge and Edinburgh communicated through two pieces of apparatus, called a 'Confraphone' and an 'Electrowriter', for a series of lectures and discussions on subjects as diverse as inorganic chemistry, molecular biology, linguistics, genetics and architecture (Perraton, Wade and Fox 1969). The Confraphone is an elaborated form of telephone, but using a free-standing microphone and loudspeakers instead of the ordinary handset so that groups rather than individuals can both speak and be spoken to. The electrowriter enables written messages, diagrams, etc, to be transmitted instantaneously over ordinary telephone lines. The trials using this equipment went on for ten days, and reactions were generally favourable despite some technical trouble. The cost

was much less than it would have been to transport the participants to either one or other of the two universities. The lack of human contact was seen as a disadvantage by many.

Graduate groups at Manchester and Sheffield also used this equipment to participate in lectures and seminars on statistics (Inter-University Research Unit 1969). Most participants liked the arrangement, though technical improvements in the apparatus were thought to be desirable. It was suggested that a network linking many universities and being used by a large number of departments would be an attractive proposition, though there might be formidable organizational problems for its effective use on a large scale.

It certainly does not appear that any system of that kind is likely to develop in the more normal institutions of higher education. Grayson's (1974) perceptive words about the openness of distance teaching to the use of new technology have been borne out in the case of the Open University, where telephone usage has developed to a significant extent since 1977. It has become of such importance that a handbook has been issued to tutors to instruct them in the best way to use it (Telephone Tuition Working Group 1979), and the OU is considering setting up a dedicated teleconferencing network linking its 250 local centres (Sparkes et al 1979). When students are comparatively few in number and far flung in space the telephone has proved to be invaluable and economic, while research has shown that:

> 'No differences between face-to-face and telephone communication have been found for tasks involving information transmission, problem-solving and generating ideas. It seems that the tasks which most frequently occur in educational settings - giving and receiving information, asking questions, exchanging opinions and problem-solving - are tasks which can be done as effectively by telephone as face-to-face (Williams and Chapanis 1976). However, tasks such as getting to know someone, persuasion, or negotiation were affected by the medium through which they were done. For example, people who have met face-to-face are judged more favourably than people who have met only be telephone. Broadly speaking, tasks in which interpersonal relationships are important are less effectively done by telephone, while those involving cognitive material are done as effectively. A number of field studies (mostly American) have compared students learning face-to-face with learning by telephone, and found the two media to be equally effective.' (Telephone Tuition Working Group 1979.)

Another interesting technical aid from the Open University stable, taking advantage both of equipment that is commonly available in the home and also of advanced technology, is CYCLOPS (Read 1978). The equipment is rather like a cassette recorder, but contains a micro-computer which enables it to feed into the TV set both sound and pictures from specially recorded tapes. The system is still in the development stage, and can only at present provide still pictures of a quality below that of conventional TV; but improvements and elaborations are envisaged by the designers and the possible benefits for Open University students are obviously great. Whether such equipment will ever have a place in ordinary higher education is much more doubtful.

One also hears rumours of even more sophisticated aids that, like CYCLOPS, will combine several audio-visual facilities economically and reliably. Behind this (or perhaps ahead, according to your point of view) loom thoughts of holographic reproducers, satellites and other equipment which only exist as yet as a twinkle in some researcher's eye. Holographs are ingenious and sophisticated devices which have the ability to produce a three-dimensional image from special two-dimensional photographs. Not only is the image three-dimensional, but you can to some degree see round its corners. Though a pilot demonstration of its use in education was given some time ago in the USA it is not something that has as yet been highly developed.

Satellites, on the other hand, have been investigated in some detail to see if they have a useful educational role to play. Daniel (1978) sums up the research in this area and concludes that they have viable applications where the potential students and geographical areas of use have some or all of the following characteristics: 'Large distances, sparsely populated areas, large or highly specialized audiences, interaction, dynamic consortia of institutions.' He warns, however, that these may be considerable political and economic barriers to implementing the possibilities disclosed by the research, which has been able to use lavishly funded time on experimental and under-used satellites. Hiring time on ordinary commercial satellites may be quite another matter - and it is certainly not a technology likely to be applicable to the small countries of Western Europe, unless an overseas connection is envisaged: for instance France has already conducted experiments with the Ivory Coast and Canada. To what extent other new devices may impinge on the educational scene it is difficult to foretell, in view of the rapidity of present technological change. Perhaps the Smellies and Feelies of Aldous Huxley's Brave New World (1932) are not so far away after all and history (like nature) will soon catch up with art.

SUMMARY

1 Research data on the effectiveness of mixed systems is not abundant in terms of increased learning; but important side-effects have been reported (see below).

2 The creation of such systems may lead to a new rigidity, but not if feedback as to the operation of the systems is properly accepted from students.

3 Apart from simple feedback, students can be beneficially used in the operation of the systems.

4 Learning is better adapted to the individual in a mixed system.

5 Teachers can be reserved for strictly human functions which the machines cannot imitate.

6 Teachers find their own time schedules easier to arrange than when using traditional methods; but may be forced to considerable rethinking of the material they wish to teach.

7 In their elaborated forms such systems can be very expensive in terms of capital investment; but they can be built up from simple items such as tape-slide programmes.

8 Technical developments are so rapid that it is impossible to predict what apparatus will be available in the future; but present-day equipment seems able to provide all that is reasonably needed.

9 Further research might well be directed towards analysis of the different effects of differently put-together systems in the search for the ideal learning environment.

6 COMPUTERS

The last ten years has seen much action on the computer learning front: the advent of microprocessors may mean that we will see even more in the next ten. In 1969 in Great Britain the National Council for Educational Technology surveyed the scene and put forward ideas and suggestions for a national development programme to see what could be achieved by using computers to help learning, and from the beginning of 1973 to the end of 1977 some £5m was spent in investigations and trials. (Total funding, including other sources, might add another million or two.) The director's final report (Hooper 1977) is an honest document which does not gloss over the difficulties of the programme, but is basically optimistic that the computer is here to stay as an aid to learning. We are not speaking here of its use as a mathematical slave in research operations or in educational administration, but of its direct uses in the instructional process to teach things other than computing itself. Before going into more detail about the achievements of the national development programme (NDPCAL) we will say something about the nature of computer assisted learning (CAL), and of computers.

For the benefit of those who are not well acquainted with these machines it may be helpful to rehearse briefly the capacities they possess, which may make them useful in education. They can be programmed to accept and process verbal information of many kinds, and some kinds of graphical work. They work rapidly and with a very much lower chance of making errors than do human calculators: ie they are fast and accurate. They can store enormous quantities of facts and figures and refer to them infallibly when required, or conduct mathematical calculations on them. In our case these facts and figures can either be concerned with the subject being taught, or with the students who are being instructed, or with the two sets together and their interactions. Computers are rigid and inflexible in some ways, and the basic operations they do are of a childish simplicity; but they give to some people a fearsome impression of massive intellect by virtue of their great speed of operation and their capacity to combine simple elements in structures of great complexity. They do not arrive at answers by sudden human flashes of artistic inspiration, but by the endlessly patient repetition of simple routines. They can make the work of intelligent programmers and teachers available to any number of students, but themselves are in no way intelligent. The programmes by which they operate can be continuously modified and elaborated as circumstances demand without the original structure being lost or forgotten: the limitations are the capacity of the computer, the supply of electricity, and the availability of good programmers and analysts.

The machine lends itself to various modes of operation of possible usefulness in learning (Black et al 1969):

1 Because of its endless patience, reliability, and record-storing capacity it can give drill and practice sessions in basic skills.

2 In the tutorial mode the computer first presents the learner with facts and examples, and then begins to ask questions relating to the information just presented. The student's learning is controlled and directed down various routes depending on his responses to the computer's questions.

3 In the inquiry mode the student is presented with problems and given different degrees of help towards the solving of them depending on the standard of competence he displays.

4 In the problem-solving mode the initiative rests with the student to present problems or specify information areas for investigation and to use the computer to assist him in his work.

5 It may be employed in simulation exercises to enable students to learn rapidly, but without material damage, what would be the result of decisions taken in various hypothetical situations; and it can take part with advantage in various procedures such as business games in which operations which would take several months to carry out in reality can be brought in a few minutes to a conclusion.

6 It is able to administer tests and especially to analyse and store the results of examinations of all kinds (Crow, Diament and Goldsmith 1969) so that teachers can base decisions about future operations on complete and accurate data.

7 In more global fashion it can undertake the task of guiding students through complete courses, specifying what materials they should use, testing them, and then indicating where they should go to next rather than acting as a kind of teacher itself.

Where the computer is used in the modes where it interacts directly with the student (setting problems or helping to solve them, providing information, etc) the process can be called Computer Assisted Learning (CAL). Where the machine is used to assess and direct students to other materials and resources outside itself the process can be called Computer Managed Learning (CML); but it is important to realize that these two processes are not mutually exclusive, and it is the fact of what happens rather than the label that matters. Also these terms tend to be used in different ways in different publications, and the word instruction is sometimes substituted for the word learning.

Confusion has certainly long been rife over terminology in this area, as it has unfortunately in other areas of higher education, and it is probably wise, as Hooper (1975) suggests, to abandon the attempt to fix a precise meaning on the different possible labels and just to say what specific part the computer is playing in any given scheme. For further elaboration and discussion of these terms and the modes of operation see Hooper (1977, Chapters 3 and 5).

As might be expected CAL (using this acronym as shorthand for all forms of teaching with the computer) has been developed on the most extensive scale in the USA. Two review papers by Sugarman (1978 a, b) have taken a hard look at all this American activity, and the author is not too happy with what he finds. Some of his more important conclusions are: Computer Assisted Instruction in the USA 'remains in the hands of a relatively small community of experts'; so far

evaluations do not show that CAL is superior to other means of teaching, apart from use for drill and practice; large-scale networks have not worked; the advent of microprocessors may change the situation by making systems cheaper, more flexible, and more locally available - what are called standalone systems; but 'Even so the question remains as to whether the $232m spent on development since 1965 could have been better used in other aspects of learning.' Zinn (1978) also gives an extensive account of development and practice in the USA, but says nothing about how effective the technique has been. The 1977 conference of the National Association of Users of Computer Aids to Learning (NAUCAL) produced the following useful list of possible computer operations in education.

1 Learning about computers:
   (a) computer literacy
   (b) data processing
   (c) computer science
   (d) professional development
   (e) in-service training
   (f) personal computing.

2 Learning through the computer:
   (a) drill and practice
   (b) diagnostic testing
   (c) tutorial.

3 Learning with the computer:
   (a) simulation and gaming
   (b) problem solving
   (c) creative activities.

4 Learning support systems:
   (a) computer managed instruction
   (b) information management
   (c) guidance
   (d) materials generation.

Coming closer to home Rushby, James and Anderson (1978) survey the European scene, and make some highly relevant points about the introduction of CAL. They discuss work in France, Germany, Holland, Sweden, and Russia, and identify the three forces that have pushed CAL forward - political, technological, and educational.

The political push has been the strongest and the educational the weakest. 'These advances have not been sought, and have not come about in response to an otherwise unanswerable educational need.' As regards the impact on the ordinary teacher they make these pertinent remarks:

> 'Sadly, although there have been enormous gains in speed and reliability for users, the designers still presuppose that the users are essentially people like themselves, highly motivated and technically competent, with a certain delight in overcoming the intricacies of operation.... Improvements which are so critically important to the effective use of computers in teaching will only be achieved by the refusal of the designers of teaching systems to accept that things need to be so difficult, and by continuing efforts to get this message over to manufacturers.'

Nevertheless, despite these forebodings, in higher education successful schemes have operated on the continent, one of the most successful operational schemes being that in the physics department at Paris (Bestougeff et al 1969) under Le Corre, using a machine on which up to twenty students can work at the same time. Over 100 instructional programmes are available in this system. In addition to physics subjects there are programmes in medical statistics, chemistry, and biology, and students who have used the system have been favourably impressed by it. Their reactions have been studied, and one of the chief findings is that the computer forces the learner to think clearly and make decisions in a way that no other teaching method does. One would suppose this was because the computer provides no extraneous clues to answers, as a human teacher does, nor any opportunity for taking a quick look at the answer first, as other aids may do. However, the extent to which students like to be forced to think logically is uncertain, and though such installations at the Paris one may work well with comparatively small numbers of (volunteer) students, judgement needs to be suspended until we see what happens when it is in operation with large numbers of less selected people.

Hartley (1978) has weighed up the situation in the United Kingdom with regard to CAL. He notes that remarkably little of the current development has taken much note of what we know about the psychology of learning, particularly the necessity to give students the chance to make reasonable decisions if they are to retain motivation - even though we know that 'students in a free learning situation do not make a good appraisal of their abilities or requirements and do not make effective decisions.' He refers in some detail to the National Development Programme (of which more below), but, like most other observers, is not entirely satisfied with what he sees, though he does not wish to be discouraging:

> 'To judge from the utilisation figures, the projects have produced materials which seem satisfactory for their purposes.... Often, though, the materials do not systematically exploit those principles that have been shown to be effective in controlling learning. The records of a student's performance are sparse, and there is little attempt to build up a representation of his knowledge and skills. So the programs are content-centred, and not based on adequate student models.... These comments are somewhat severe, bearing in mind the limited time-scales and resources of NDPCAL projects. The prime needs have been for a considerable quantity of materials to be produced and validated quickly. These aims were accomplished.'

McMahon (1978), in a complementary article to Hartley's, surveys the area of Computer Managed Learning in the United Kingdom. He describes the Open University's CICERO system, and International Computers' CAMOL system. CICERO has terminals in most of the OU's local study centres, while CAMOL includes a dozen or so institutions. CICERO is essentially an interactive process to help individual students; CAMOL has more overall record-keeping, reporting, and assessing functions, though it also helps individuals. Unfortunately nothing is said about how successful these systems have been, though CICERO, in particular, gets plenty of use.

Hartley's and McMahon's surveys lead us naturally back to the achievements of the National Development Programme (NDPCAL). Some of the facts and figures

connected with it are not too easy to sort out, because NDPCAL's funding and operations overlapped with other smaller sources and programmes, and because the funded projects varied widely in nature; but the general picture is reasonably clear. The final report (Hooper 1977) lists thirty-five projects, the majority of which are in higher education. Fuller details of the projects and the computer programs around which they are based are given in the Project Summaries and Program Index (National Development Programme in Computer Assisted Learning 1977). Altogether some twenty-eight universities, polytechnics, and colleges took some part in the work, involving hundreds of teachers and thousands of students. As was expected the subjects mainly involved were comparatively few in number: statistics, engineering, physics, mathematics, medicine, biology, chemistry; and within these subjects only certain limited topics were generally programmed. In addition there was also some work in business studies, psychology, sociology, linguistics and a few others. All in all a considerable activity was evident, and a large number of people were alerted to the possibilities and limitations of the computer as a teaching aid. Not only that but, conscious of the way development activity in education tends to stop when research money stops, the NDPCAL made determined efforts to make sure that institutions continued the work after its own demise, and, as of 1977, it was reckoned that 70 per cent of the projects would keep going. The cuckoos would not be rejected from the nest. An Association for Computer Assisted Learning has also been formed to keep interested parties in touch, and academics in many places are looking at what more might be done.

Despite this impressive body of evidence doubts still remain. Formerly it had been hoped to save money by using large computers to disseminate teaching materials to large numbers of students in many places; but experience shows that CAL is always an add-on cost, and therefore in a time of financial stringency, an activity that is likely to be cut, unless some major benefits can be shown to accrue from its continuation. Certainly students generally like it; but that is not usually a sufficient reason for adopting an expensive teaching method. Also, as Hartley (1978) emphasizes, the computer has never been the central feature of any of the teaching schemes in which it has been used. It certainly works; it does the jobs allocated to it if the project is a well thought-out one (and most of them have been); but as Sugarman's review of American work indicated there is perhaps only one teaching function (drill and practice) in which it can claim a really useful place; and it cannot speak for itself in faculty boards and senates. Perhaps the greatly reduced cost of micro-computers, and their ease of installation and use, may turn the tide, especially as university scales of expenditure can accommodate the relevant budgets more easily than can schools; but more probably this technique will remain in the present slightly uneasy stage of development until it has become as cheap and easy to use as our familiar criteria: the stick of chalk and the book. It is notable that a thorough and authoritative study of micro-chip possibilities hardly mentions education (Barron and Curnow 1979). Perhaps the only genuine use for computers in higher education will always be number crunching and administration and record keeping.

One excellent feature of the national programme is that it evolved a system of on-going evaluation of its projects (Centre for Applied Research in Education 1975); but the interim report of the evaluation was not at all what traditional researchers in this field expected, and was, apparently, not all that welcome to

some members of the programme steering committee. Aware that much money had been wasted, principally in the USA, on developing computer assisted learning programmes which no one subsequently used, the report did not deal with how well students learnt from the projects, but was principally directed at the social question of the acceptability of the projects and the likelihood of the continuing use of computers in teaching once the research projects came to an end. We can fittingly conclude with some quotations from the report which, in relation to this most sophisticated and costly of aids, make many points applicable to most of the other apparatus we have discussed.

'This voraciously expensive technology is still in its infancy, and has already consumed vast sums in America and several fortunes here. There is little to show for it. The confident promises of economies of scale, premised on twin fallacies of standardized needs and compliant consumers, have not generally been fulfilled, and the resultant reappraisal of costs has led to some rapid abandonments when the prop of external support was withdrawn.' (p. 46)

'Of all the institutions which make up the educational system the university appears to be the most resistant to alteration. There are many reasons why this should be so, in addition to career structure. Secure élites are not given to self-criticism.' (p. 47)

'The belief that innovations succeed on their merits... has never been much in evidence at the centre of the National Programme and is becoming rare in the outstations. It is generally assumed that the citadel of established practice will seldom fall to the polite knock of a good idea. It may, however, yield to a long siege, a pre-emptive strike, a wooden horse or a cunning alliance.' (p. 49)

'A major condition of acceptability in some settings is perceived to be the demonstration of educational excellence, rather than the capacity to deal efficiently with tiresome teaching chores.' (p. 52)

'Most projects which have produced evaluation data... have been in a position to report on student attitudes. These reports have been generally favourable. Students have expressed enthusiasm about the novelty of the computer and about the opportunity to interact with it.... Some problems of negative attitudes have emerged, most often in consequence of failure of the computing arrangements, breakdowns, line noise, delays, etc.

'In general, teachers involved with CAL seem favourably impressed by it, more excited when they are involved in creating CAL materials, and less favourably impressed if they are invited to accept packages which are constraining.... Some projects have developed strategies for involving non-committed teachers in their institutions, mostly through the use of demonstrations. In many, the problems of involving increasing numbers of teaching staff have made plain the political nature of innovation, and have made manifest institutional sensitivities which were previously latent.' (pp. 28-29)

SUMMARY

1 Computers can perform a wide variety of tasks to help learning, but probably are best used in certain restricted ways.

2 Computers probably force students to think logically in a way that no other aids or teachers do.

3 Much money has been spent on developing the computer as a learning aid, but not nearly so much on research into its operation in this capacity.

4 Higher education seems a natural field for further development.

5 Micro-computers may reduce the cost and enlarge the scale of computer applications.

DISCUSSION AND SOME CONCLUSIONS

The picture that we have presented is not a clear one. We are living in the middle of a technological revolution, and it would be surprising if in such a period of change we were able to make any final, definitive pronouncements about the topics we have dealt with. All we can do is to point to certain features which may be of significance in forcasting the way in which development may move. Technical progress is rapid, and what the future may hold is difficult to foresee. Human beings, though perhaps evolving rapidly on a geological time-scale, are changing much more slowly than their own creations. The academic world, in particular, likes to be quite sure of its ground before accepting anything new connected with teaching. The problem of transplanting new technical aids into the educational body resembles that of the much publicized organ-transplantation in the medical world. The key question is not: 'Does the instrument work?' but 'Will the academic body accept or reject it?'

For instance: at the end of the previous section we touched on the possible reaction of students to attempts at teaching them by computers. It is probably even more important to try and elucidate the ways in which teachers may view the large scale introduction of such sophisticated hardware, because teachers have more to say in what goes on in education that do their pupils. * The trans-Atlantic omens are not good. In our introduction we mentioned the topic of audio-visual aids being hurriedly bought and extensively under-used (Graves 1968a), and a substantial study of the attempt to introduce television teaching into an American university makes gloomy reading for the dedicated audio-visual aids man (Evans and Leppman 1968). Having taken an intensive look at one institution the authors checked their results by discussion with staff at nine other universities. They found that students generally did not like television courses, even though they learnt as well from them as from other methods. As regards staff the authors came to the following conclusions:

1 A large majority of staff were hostile to television, either because it seemed to represent a threat to their existence, or because they thought it a plaything irrelevant to a serious academic education.

2 Staff feared strongly that television would lay their teaching open to scrutiny by their colleagues.

3 Most staff thought that while television might be useful for some other subject it was useless in their own.

4 Attitudes to television were correlated with teachers' perception of their role, and not with institutional structure. 'We were impressed with the

* The sporadic agitation for more student participation in educational decision-making seems unlikely to bear much permanent fruit in most institutions. The majority of students prefer to leave things to the teachers.

apparent consistency of attitudes towards television, regardless of an institution's size, its urban or rural location, its sponsorship, or even its past experience or inexperience with television as an instructional device.' (p. 136)

5 Television is started in an institution where there is an enthusiast and a source of money, or there is great pressure of student numbers. It is normally discontinued after a short time; or only kept going in a nominal and minor way. Reasons given vary, but the pattern remains the same.

6 Younger staff tended to disfavour innovation because it might make them unpopular with senior staff and spoil their careers. Older staff inclined to dislike innovation because it involved change in habits which suited them.

If this American pattern is infallibly to be repeated over here then it would hardly seem worth anyone's while to invest money in the equipment mentioned in these pages.* Apart from any local initiative the Brynmor Jones Report (HMSO 1965) set in motion a lot of activity in the development and use of audio-visual aids in higher education, and it would be unpleasant to think that the investment represented by this activity was not going to yield a good return. 'We have become increasingly convinced that these aids can help to improve the quality of teaching and enrich learning processes', says the report (p. 111 Summary of Main Recommendations); but unfortunately no scientific evidence is adduced to back this conviction. There may therefore be a real danger that money expended on these aids is going to be largely wasted unless we can try and see what went wrong in the USA and take proper warning.

The Council for Educational Technology for the United Kingdom (formerly the National Council for Educational Technology) has been well aware of this need to learn from American experiences, as is exemplified in its pronouncements about computer assisted learning in its earlier days (Black et al 1969; NCET 1969a, b). Unfortunately there is a strong tendency in educational innovation to re-invent the wheel, and also to consider local circumstances so special as to make almost any experience elsewhere inapplicable. Such attitudes are among the factors which tend to slow down beneficial change in teaching. They are not insurmountable obstacles to improvement, but they cannot simply be ignored. We must therefore consider both what is necessary to make innovation more rational and acceptable, and also whether there are any factors already present in the educational scene which may assist the process.

To deal first with the second category, the helpful factors already there: it is clear that teachers are prepared to try out new things, eg slides and overhead projectors, if they do not disturb the previous pattern of teaching, do not cost much money, are easy to handle, do a given job at least as well as whatever they replace, and are not likely to need a lot of maintenance and technical care. The teacher's traditional ally is a piece of chalk, and the closer any modern aid approaches this still indispensable material in some respects the more likely he is to use it. Chalk is cheap, readily usable in a variety of circumstances, portable,

* For a thoughtful and provocative discussion of the American situation see Oettinger and Marks (1968).

does not protest at being mishandled, and can be thrown away without pangs of conscience when you get tired of it. Anyone who is trying to convince teachers of the value of a new audio-visual aid should bear these points in mind. Researchers and administrators tend to forget one or more of them because from the research and administrative angle they do not look important. Teachers, however, will not be slow to take up anything new and to develop its use, without benefit of elaborate research projects, if it approximates to the chalk criterion suggested above. This is a fact that should be of comfort to the man who really has got something good to offer; but how can he be sure he has?

It may be suggested that the answer lies in some form of the process generally known as Systems Analysis, to which many educational thinkers are now turning. CET favour this approach; OECD have published a useful bibliography (1969) and much American work has been devoted to it (Smith and Smith 1966). The name may be new to some, but the process itself is neither new nor difficult to describe in outline - implementation is another matter. Though it is used freely in the physical sciences it is not so easy to apply to human affairs; but it does hold out more hope for successful innovation than most of our present haphazard and inconclusive operations, emotionally satisfying as these may be for a time. Essentially it means that if we want to produce beneficial changes in a system, eg of education, we try first to create a (mental) model involving all the factors that seem relevant to the system, quantify as many of these as possible, and then work out possible outcomes if the system is set in motion. We can thus hope to distinguish between the importance of different factors, and by patient study continually improve our model: by adding in new factors where they seem to be needed, or by modifying or discarding existing factors and changing equations. It is by some such operation as this that meteorologists have been able to develop a pragmatic model of pressure pattern changes better for short-range weather forecasts than the intelligent guesswork of human forecasters. We may hope to do the same for education by a similar patient process, though the job is likely to take longer and need a bigger computer. (The Met. Office needs the biggest one commercially available.) A really exhaustive analysis may have to bring in many factors from outside the classroom, but these are probably less important in most cases in higher education than when we are considering the educational problems of such groups as immigrant children. It is therefore legitimate for most teachers in higher education to confine the investigation to the immediate factors of the teaching-learning situation. At any rate this should give a reasonable first approximation: if it does not, then additional outside factors must be brought into the calculations.

One way of looking at the situation is that dealt with by Heidt (1978). He reviews the use of technical aids in learning, and examines various theories and ideas about their proper place. He favours what is called the Trait-Treatment Interaction (TTI) approach, which emphasizes both the individuality of the learner, and the fact that technical aids are not merely 'more or less neutral carriers or vehicles of information, but objects which, because of their structural quality, control or at least fundamentally influence the learning process.' He insists that the kind of question hitherto most commonly researched, eg 'which medium (eg film or textbook) is better or more efficient than the other', should be replaced by 'which media attributes are relevant for learners with which personality traits for which kind of learning tasks.'

This involves studying intensively the characteristics of particular aids and also of the actual instructional processes and people with which it is proposed to involve such apparatus. By doing this we may hope to make sure that the aids' characteristics will actually meet a real need and not be irrelevant, unhelpful, or frankly deleterious. The point has been firmly grasped by some workers in England. See, for instance, the excellent discussion, particularly by Engel, appended to the paper by Harden, Lever and Donald (1969). The expert who merely knows about the machines cannot give the kind of advice and help that teachers need. The audio-visual expert must also be an educational expert to be of real use.

Lumsdaine and May (1965) make this point among many others in an extended review of American experience with the new machines. 'The art of producing films, television materials, and other kinds of instructional programmes... depends in large part on the extent to which the producers or programmers understand basic principles of learning and can manipulate the conditions under which they will apply.' (pp. 495-496.) They show how confusing and divergent are the results of many technical-aid experiments, and comment: 'Review of the literature reveals that relatively few of the experiments under consideration were planned to test hypotheses derived from learning theories; and relatively few reports contain any theoretical considerations of why the results should have come out as they did.' (p. 496.) Admittedly learning theory is not in a clear state at present, and perhaps does not take enough account of individual differences; but it is at least a disciplined attempt to penetrate beyond the superficial appearances of the situation and is therefore worthy of taking into consideration. The same, unfortunately, cannot be said about many of the experiments we have reported earlier, particularly the crude kind that compares a specified aid with 'conventional' teaching. To quote Lumsdaine and May again: 'The frequency of such studies doubtless betokens interest in an important and legitimate practical question: one obviously wants to know if an innovation will improve things. Unfortunately, even if we had (as is seldom the case) either demonstrably stable and reproducibly-defined 'conventional' procedures, a representative sampling of such procedures, or both, results of most such studies would apply only to the particular program(s) tested, not to a whole class of media.' (p. 494.) One point to be emphasized is that a proper evaluation of traditional methods is necessary at the same time that new media are being assessed. Otherwise there is a tendency to compare something new with an unattainable ideal and to condemn it because it falls short, without reflecting on just where the traditional methods stand in this respect. Also, lurking in the background, is a thought that bothers many conscientious teachers: we are all individuals, our students are individuals - yet we usually insist on batch-processing them. Can we hope to find really good answers to procedural problems while this basic mismatch rules the educational scene?

The message is clear. Before a teacher plumps for films, television, CAL, teaching machines or any other bolt-on goodies he must first discipline himself to a clear analysis of the total situation in which he hopes to use the new device. For this he may be able to get advice and assistance from a local audio-visual unit or staff development unit, such as are becoming increasingly common in higher education in the British Isles and elsewhere; but this advice will only be valid if the man at the unit knows about education as well as electronics, and if, as was pointed out in our general introduction, the teacher is clear himself as to what he is really aiming at.

In default of expert advice from a local unit it is not to be expected that most teachers will be able or willing to attempt immediately a full-scale analysis, but provided a genuine effort is made to set about asking questions in the right way, and to answer them clearly and scientifically, some good is bound to come of the exercise. At the very least the ground will have been cleared for further analysis of factors which at first sight do not seem important. It is the attitude which is important, because the right approach leaves the way open for future development and growth. Let us suppose, for instance, that two objectives of the ideal school would be to provide each student with:

1 Learning materials and apparatus that would cause him to know clearly and understand fully whatever he was required to learn; and

2 A perfectly informed and psychologically infallible counsellor at hand whenever needed.

The honest teacher, conscious of his own inability to come as close as he would wish to such lofty ideals, might inquire in which ways technical aids might help him to approach these objectives.

It may be suggested that programmed learning makes some attempt at the second task: the infallible counselling; and that ultimately computers may come closer to it; but that at present audio-visual aids are best used to fulfil the first task in those cases where the traditional book does not provide the complete answer. The spoken and written verbal material to which the teacher is so well accustomed, and which is so meaningful to him, may only leave a vague and superficial trace in the mind of the learner. He has not enough experience to make words on their own adequately meaningful though he may be able to reproduce them in an examination. It is here that properly used technical aids can be so useful in deepening and clarifying learning. Nevertheless it is worth noting that a perceptive review by Janowitz and Street (1966) of the relationship of modern aids to the educational process puts forward a reasonable case for the fact that the paperback book is the best of them all, as far as most students are concerned. Chalk for the teacher, books for the learner: these are the two standards against which other non-human teaching devices must be measured, and the teacher contemplating a new departure in technological matters should ask himself all the time: can what I hope to do be done better in this new way than by these older methods? In certain limited circumstances the answer is probably 'Yes', but in many it is 'No'; and one reason for the wholesale rejection of technical aids in the USA is that insufficient attention has been paid to the bounds within which they can be expected to function well, and the too easy assumption has been made by technologists and theorists that teacher and students will be content to be pinned down and systematized by mechanical objects.

We can make some attempts to clarify and summarize the evidence that has been presented earlier, by spelling out in more detail the sort of questions that a teacher should ask when contemplating the use of particular aids. Once he is clear about his immediate instructional problems he may then have to tackle what are often more intransigent technical and administrative problems, but we will not at present venture further into these. On a practical level, if he is thinking of using moving pictures, he should give himself such a catechism as follows

1 Do students need to see an activity taking place in circumstances which preclude a large audience because the audience would itself affect the activity, eg psychiatric interviewing, class behaviour in schools? (films, television)

2 Do students need to see activity that is at a distance, in dangerous or confined places, too fast or too slow for normal viewing, on a very large or very small scale, only possible in one place, eg medical or dental operations, microscopic phenomena, weather development, plant growth, nuclear experiments? (films, television)

3 Do students need to see their own behaviour, eg trainee teachers, orchestral conductors, psychiatrists? (television)

4 Do students need a clear demonstration of a technique before they put it into practice, eg in an engineering laboratory or dental school? (films, television)

5 Do students need to see activity that it would be inconvenient, even impossible to do at short notice on the spot, eg drama excerpts? (films, television)

If the answers to any or all of these questions is 'Yes' there is an embryo case for films or television or both, or, failing these, some sort of tape-slide system. The pictures are being used to do something which cannot easily be done in any other way, and are acceptable to both staff and students. Where movement, or activity, is not of critical importance the teacher may ask himself questions similar to those above with regard to still pictures.

Questions with regard to the use of recorded sound would be closely similar, and apart from the obvious cases of music and modern languages, would probably only be applicable in a few specialised cases, eg heart sounds in medical teaching. The provision of adequate drill and practice for language students is another teaching activity in which machines can be a real help, analogous to the repetitive work that computers can provide for statistics students.

One question which has often bedevilled the issue with regard to moving pictures is one which has been posed as an instructional one, but is actually of an administrative or technical nature. The question is:

> 'Is space so short and/or numbers of students so large that it is impossible for a course to be given to a whole class at the same time?'

When the answer to this question is 'Yes' the administrator with money and technical resources turns thankfully to closed-circuit TV which can be relayed to other places from the lecture hall as the lecture is actually going on, and videotaped for projection later. If the lecture has been tailor-made for the occasion this may work well; but if not, unfortunate long-term side effects may accrue. Some of the experiments reported earlier (eg Coney et al 1969; Evans and Leppman 1968) indicate that though such use may not be deleterious educationally over a short period, in terms of such things as examination results and superficial learning it is liable to provoke large-scale rejection phenomena when it is used for long. In an emergency or for special occasions - yes; as a staple item of instructional diet - no.

The idea of a staple diet leads us directly on to another set of questions which may well be of crucial importance to the teacher. Is there anything he wants done often by the class, which he hasn't got the time to attend to continually himself, but which technical aids might do for him? In such a situation, eg learning the basic facts of a subject, such things as tape-slide systems or short 8 mm films may be invaluable. The difficult problems here are more often of a technical or administrative nature: to find the space, time, money and equipment to get the system going. (There is a critical size below which it is unreasonable to expect such systems to be useful. One would not expect a library of two books and three reprints to make much impact on an educational programme.) The teacher must also accustom himself to the idea of students using the equipment in his absence, in their own time; and many teachers do not like this idea. They are fearful of things escaping their control.

It is worth considering in a little more detail just what elements in the learning situation still pictures and tapes supply. In all learning that is concerned with material objects or biological entities the ideal thing would be for all students to have before their eyes the objects they are supposed to be learning about. Words, whether spoken or written, will then have something precise to anchor themselves to. Failing the actual objects themselves, or models, still pictures bring the next best thing to students: they provide significant foci around which the flow of words can crystallize into meaningful assemblages much that might otherwise be dispersed or evasive. They make the memory traces in the mind deeper, sharper and more adhesive. Similarly the audio-tape can be the surrogate for the human being for those learners to whom the spoken word is more meaningful than the printed page. Both these aids are commonly used, the former particularly, in many conventional teaching institutions; but it is as combined systems, able to make routine knowledge flexibly available under good conditions, that their most promising line of development would seem to lie. The best developed forms of such a system, such as that at Purdue University (Postlethwait, Novak and Murray 1972) have this flexibility and so can make the maximum allowance for individual differences. A possible danger of such systems is insufficient human contact, but those that function well have this vital ingredient amply built in, as adequate systems analysis would show was needed. In fact the teacher is able to play a human part than in many conventional teaching situations: he acts as guide, philosopher and friend rather than as a drudging processor of rote information (or he can find a satisfying task in perfecting material for the system) (Garland, Dutton and MacQueen 1977).

For instance, audio-tapes, which may be rejected as mere disembodied voices when used on their own (Snyder, Greer and Snyder 1968; Flood Page 1967) are much more acceptable when the students know the person that produced them and can see him at hand, and talk to him, (Postlethwait, Novak and Murray 1972). Similar considerations apply to filmed demonstrations (Pearson and Jepson 1969). Instructionally such arrangements would appear to have much to offer, but administrative and technical obstacles to their fulfilment may be massive.

As regards programmed learning, teaching machines, and all the ideas and devices associated with them, the accounts presented earlier suggest that overmuch elaboration on this particular theme does not warrant a lot of attention in higher education, and in particular that machines are a poor investment.

The extent to which there will be wide use of the most sophisticated development of these activities, ie computer mediated learning, is still a debatable point, though enthusiasts for microprocessors feel that these particular bits of electronic wizardry might cause a breakthrough, or break-out, on this particular front. Doubts certainly still cluster round this issue. Nevertheless, if teachers are prepared to accept the central tenets of the technique then much that is valuable for students may be produced. This means that teachers must be ready to adapt their teaching material to the stage and pace their learners have actually reached, and not to the stage that the teachers have reached or think the students should have reached. It also means that if material is tried out and fails to provoke adequate learning, it is the material which is patiently and thoroughly revised in a scientific spirit, not the learners who are blamed in an emotional catharsis. These things are easy to say, but seem to be almost insuperably difficult for many teachers to do. To explore the reasons for this barrier would take us much further into psychology and sociology than we have space for here, fascinating as the prospect is; and necessary as it is for a full analysis of many educational problems.

We have not attempted to summarize in this section comments and evidence on all the aids mentioned earlier, but have tried to provide a guide to some of the more useful aspects of some of the better known apparatus, basing conclusions, as far as possible, on the reported research. It is suggested that much of this research is misguided, because it has been concerned with non-significant variables. It has, however, performed a valuable ground-clearing operation, and makes clear how much we need to know about factors which have often been ignored, but whose importance is now becoming plain. These factors are psychological, sociological, and even physiological (eg Severin 1967; Corcoran and Weening 1969). For instance, we need to know with much greater precision how the mind should be prepared for study, and how it works when a person is learning, how exactly different methods of teaching impinge on the eye and the ear, and what are the processes that link them to the brain. Clarification of such issues as these will encourage a much better analysis of the total educational problem, and therefore help us to specify more exactly the correct part that technical aids have to play. For a thorough, if at times a bit ponderously teutonic analysis of many of the problems of matching students and technical aids see Heidt (1978).

One question that we have not answered directly, but which most teachers in higher education are bound to ask automatically is: 'What difference are these gadgets going to make to my students' examination results?' The answer is unexciting: in the short term, unpredictable, but probably little, unless you are a bad teacher; in the long term, more chance of improvement, but none guaranteed. This is understandable if we consider just where technical aids fit into the scheme of things, and what ordinary examinations test. These latter normally test verbal learning only, often at a superficial, easily obliterated level. Technical aids do not usually affect strongly the verbal part of the student's performance in higher education examinations. (His capabilities as regards written technique have been largely fixed at an earlier stage; and the ability to remember things and the capacity to express them clearly on paper are not linked in any obviously predictable fashion.) What technical aids can do is to make more durable and meaningful the concepts, ideas, and objects to which words have reference. They add weight to the ballast of the mind, and may play a long-term part in sustaining interest and attracting students to continue with a subject. It is unwise to expect more than this,

but this is a gain not lightly to be disregarded. Some might say, in fact, that it is a more desirable objective than examination results, though difficult to measure. Gruber's sensible analysis of the situation (1968) is worth quoting here. It suggests some reasons why so little research on technical aids in educational contexts has produced anything positive in the way of guidance to teachers worried about examination results.

'Most research on educational method has been restricted to the piece-meal comparison of methods in a single, one-term course, or in a fragment of such a course. Where the criterion variable has been assimilation of subject matter, a wide variety of methods has proved roughly interchangeable - methods as disparate as many lectures, a few lectures, instructor-led discussion, instructorless discussion, individual study with little or no guidance as to sequence or timing of material, and tightly programmed instruction. Slightly positive results favouring one method in one study are balanced by slightly positive results favouring another method in another study. In short, success in meeting the criterion of coverage of course content provides no firm basis for choice among teaching methods.

'Perhaps the reason for this negative result is really very simple, and all we need to do is to abandon our cherished belief that different educational methods have different effects. But it is also reasonable to consider the possibility that these experiments have left the essential features of higher education intact, for in almost all these studies the following variables have not been touched:

1 the student's academic work is divided into five or six courses per term;

2 the teacher plans the course without consulting the student;

3 the student is given no new stimulation in the educational aim of becoming educationally independent;

4 the student is given no specific instruction in active modes of thought which might transform his behaviour while he is studying;

5 the immediate aim on which all students are necessarily focused is successful performance in a final examination and satisfactory marks in the course; and

6 the person evaluating the student's performance is the teacher. Operating within situations that are alike in these essentials, the student studies in approximately the same way, whether the material is presented in the form of a lecture, conventional text-book, list of readings, or programmed text-book: he decides what the teachers want him to know and he tries to learn it with the minimum of distraction. Conclusion: "promising results in the expected direction, but no significant difference."' (pp. 53-54 Slightly anglicized.)

One further consideration. Another thing that frequently bothers many of the idealists who inhabit senior common rooms is the thought that they must create a perfect system of some kind before anything new is going to be tried on the students. They forget that students are not mere passive recipients, and can themselves play a large part in helping to improve an educational system, especially if they are convinced that genuine efforts are being made to benefit them, and if they are brought into the planning process at a level which is meaningful to them, ie the

actual preparation of course material. For instance, the video-tape experiment reported by Maclean (1969) makes clear how students' attitudes change when they themselves are involved in production, and also indicates that it is not technical perfection of material that is the most important factor in controlling what is learnt from a given aid - though mechanical smoothness and technical reliability in a machine is another matter. (Machines must work 100 per cent when teachers and students want them to.) In this connection we may quote two interesting pieces of work, both concerned with underlying principles rather than specifically with higher education. Embling (1967) describes how children in a junior school in Hertfordshire were given a lavish assortment of technical aids to use during a whole school year, so that the effects which followed from this rich provision could be compared with those of normal teaching. It was noted that the children acquired great confidence and competence in handling the equipment, that their demands for books increased, that they were better able to concentrate despite rising noise levels, and that the slower ones found learning more congenial because they need have less recourse to the written word. There is food for thought here. Gerstberger and Allen (1968) studied nineteen engineers in two divisions of a large electronics firm to see what were the significant factors in their selection of information channels as aids to problem solving. A direct relationship was found between perceived accessibility of information channels and several objective measures of utilization; but not between utilization and technical quality.

In other words, given a choice, students are much more likely to use educational aids which they see and feel to be easily available than those which the teacher assures them are technically very good, but which are not around when they need them. It may be reasonably hypothesized that once certain threshold levels of competence are surpassed by any aids to learning, either human or non-human, then availability becomes a much more important consideration than technical ingenuity or massive erudition. Students will tend to learn from what is readily to hand, whether you want them to or not, and will pick out what they need from the environment, provided they have a reasonable idea where they're going. Experiments such as that reported by Rubadeau (1968) would seem to bear out this contention. Students who were not given a lecture course, but could ask questions of a teacher when they wanted to, learned just as much as those being given a traditional lecture course, and took less time to learn the same amount.

This simple principle of availability is one whose value has been realized in fields outside formal higher education, as in the paperback trade and some well-known grocers. Once the principle is acted on the quality of the materials available can be steadily upgraded, in the knowledge that effective use will at once take place, as we have indicated in our accounts of multi-media systems; but if material is improved without enough thought being given to availability, much meticulous work on the part of the teacher may be wasted. (A parallel situation is the unfortunate case, so well known to us all, when an important visiting lecturer arrives and finds only a handful of students to hear him.) Such concepts and ideas as those are all part of the Copernican revolution which has been postulated as necessary in higher education, the revaluation which presupposes that the best higher education is geared to the way the learner learns and not to the way the teacher teaches. Properly used, many of the devices and systems we have documented in these pages can play a useful part in such a revolution. Among other things they can relieve the teacher of much drudgery and repetition and they can deepen a student's

perception and increase his interest; but these things can only develop towards an optimum situation when the total process, both human and technical, is continually subjected to a thorough scientific systems analysis, in a humane and reasonable spirit.

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